POWER

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The Chronic Grouch

By Rufus T. Strohm

HIS face, which bears a look of pain, is longer than a country lane, and both the corners of his mouth curve sharply downward to the south. He has a slow, dejected gait, as though he had to tote a freight of over-ripe and aged woes that had begun to decompose. His aura shows a shade of blue that's just as cheerful as the flu, and one could almost catch the pip by looking at his lower lip.

His fellow-workmen never hear him speak a kindly word of cheer, nor do they ever see a grin between his forehead and his chin. For when it comes to cracking smiles, Job had him beat by forty miles. He's just as pleasant as the itch, the hydrophobia and sich; which means, of course, that none would weep if he should fail to wake from sleep—though those who know him best would feel that Satan got a rotten deal.

No matter what the job he gets, he stews and fumes, he rants and frets, and calls the boss the meanest man that's walked on legs since time began. But everybody's well aware that all his talk is heated air and that he simply must unload or else he'd probably explode. Still, no one pauses at his side; instead, the passers-by step wide. Throughout the plant, from end to end, there's not a man he calls his friend; and all he gets for being mean and turning loose his spite and spleen is all the lonesomeness there is, and sullen wrinkles on his phiz.

New Armour South St. Paul Plant

A plant of varied equipment supplying power, light, heat, hot water, compressed air and refrigeration to a large packing house. High economy is insured as exhaust steam requirements are practically balanced with exhaust steam produced.

A NEW packing plant to serve the Northwest has been built by Armour & Co. at South St. Paul, Minn. It will be somewhat larger than the existing plant at Omaha, and, like all institutions of the

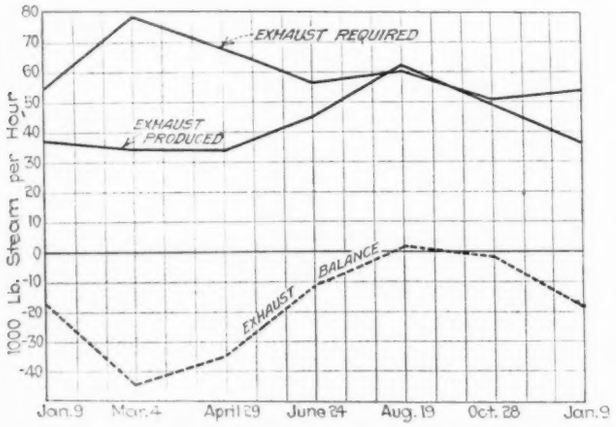


FIG. 1. EXHAUST STEAM BALANCE FOR DAY LOAD EXCLUSIVE OF GENERATING UNITS

kind, there will be large requirements for water, steam, refrigeration, light and power and compressed air. Consequently, a power plant with diversified equipment was essential and much of it steam using, to meet the large demand for exhaust steam by the various processes in the packing house. To insure high economy it was necessary to so select the equipment as to make it feasible to effect a close balance between the amount of exhaust steam that might be produced and the requirements of the packing plant.

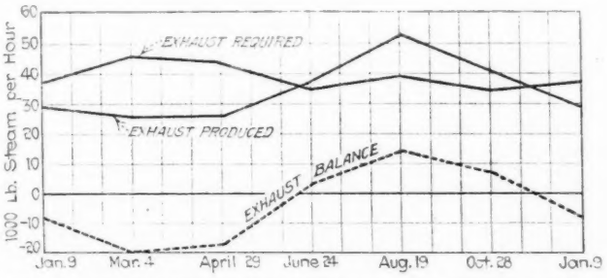


FIG. 2. EXHAUST STEAM BALANCE FOR NIGHT LOAD EXCLUSIVE OF GENERATING UNITS

To provide flexibility, the refrigerating plant was divided into compression and absorption systems, one producing exhaust steam and the other using it. The ammonia compressors are served by a barometric condenser that may be utilized if the demand for exhaust steam is low, the water from the tail pipe being used for domestic purposes or for boiler feed, so that the heat gained from condensing the steam is not lost. Normally, however, the exhaust goes direct to a 5-lb. exhaust-steam line that makes a circuit of the entire plant and supplies all requirements for low-pressure steam. The air compressors are operated noncondensing, as are

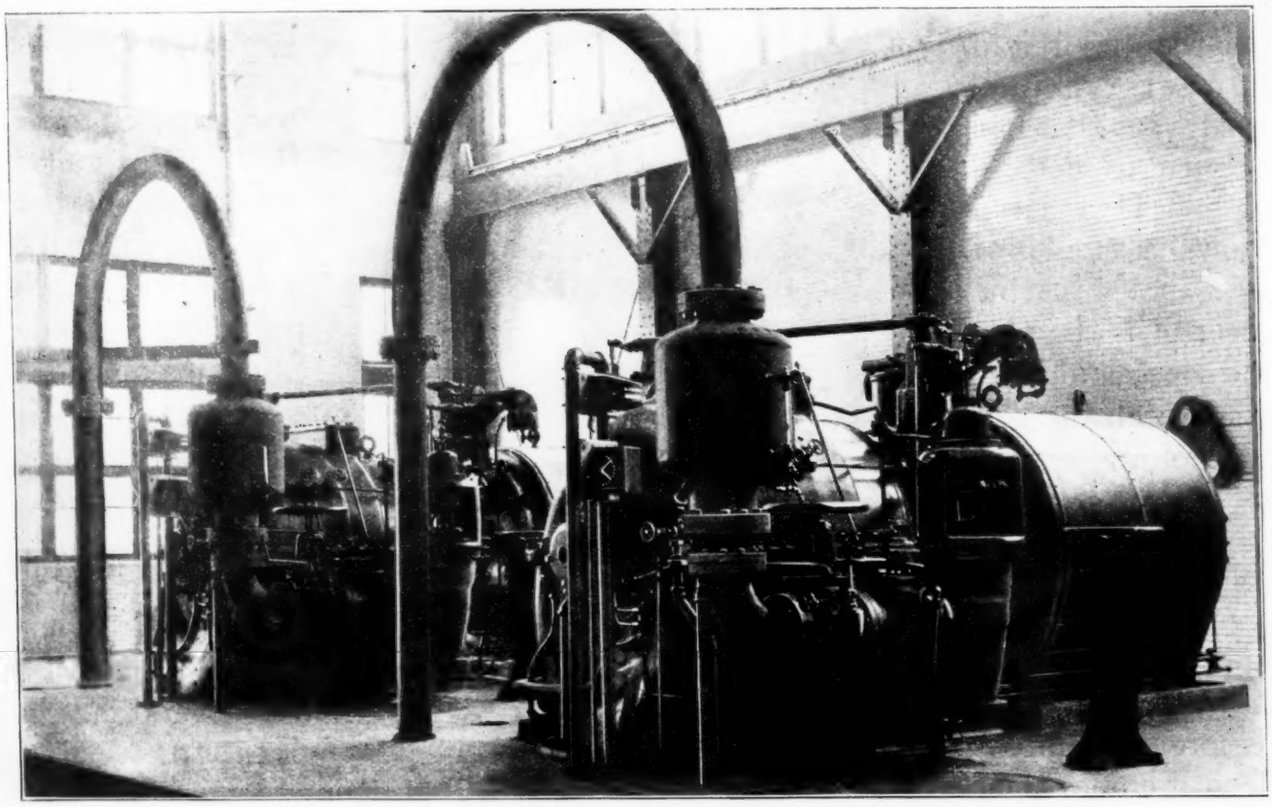


FIG. 3. MIXED PRESSURE EXTRACTION TURBINES

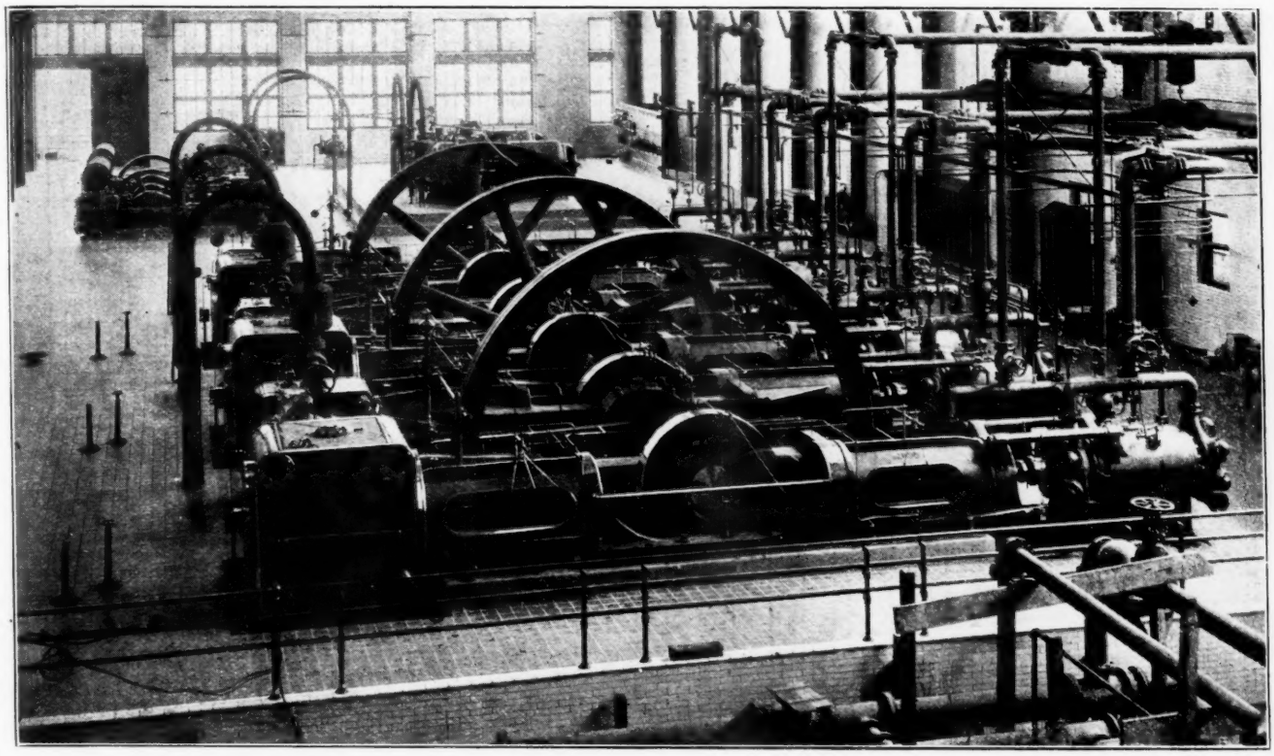


FIG. 4. AMMONIA COMPRESSORS WITH TURBINES AND AIR COMPRESSORS IN BACKGROUND

all auxiliaries in the plant for the exhaust steam that they will furnish. The prime movers of the generating units are turbines of the mixed-pressure extraction type from which steam may be bled into the exhaust line or

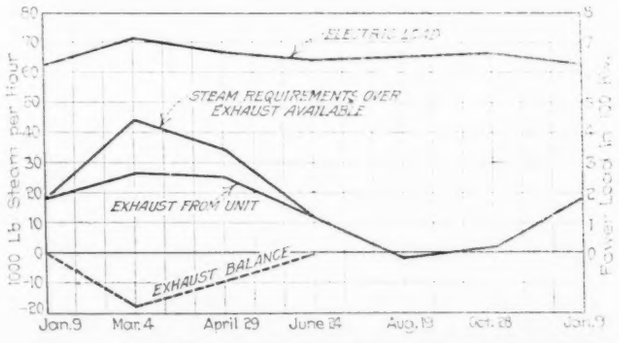


FIG. 5. EFFECT OF GENERATING UNITS EXHAUST DAY LOAD

the flow may be reversed automatically from the line to the turbine, depending upon the pressure in the exhaust line, which is influenced by the supply of and the demand for exhaust steam. There is thus sufficient

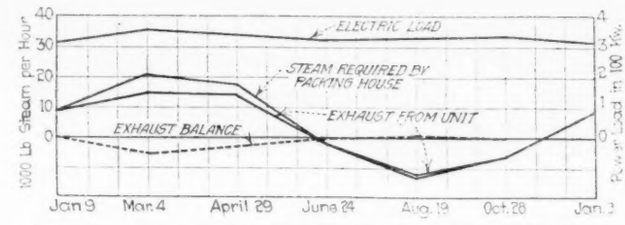


FIG. 5. EFFECT OF GENERATING UNITS EXHAUST NIGHT LOAD

flexibility so that an exhaust steam balance may be approximately maintained for the greater part of the year. During the winter months, with the heating load added, a deficiency in exhaust steam requires supplemental use of live steam reduced to the proper pressure. At no time is a surplus of exhaust expected, owing to the type of turbo-generators employed.

Such desirable operating conditions were the result of careful preliminary analyses, based on unit data ob-

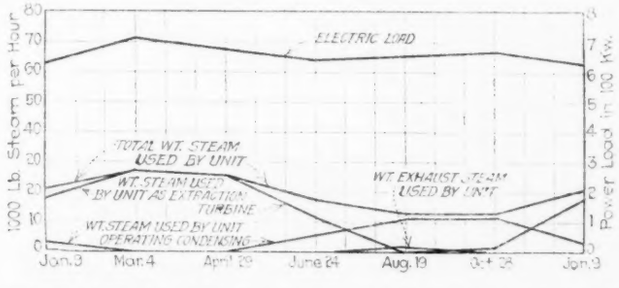


FIG. 7. STEAM USED BY GENERATING UNITS, DAY LOAD

tained from other plants of the company. With the types and sizes of the varied equipment of the plant tentatively selected, the hours of service and the requirements of the packing house determined, a careful estimate was made of the exhaust steam required and that

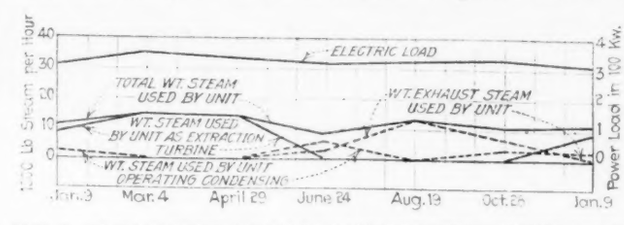


FIG. 8. STEAM USED BY GENERATING UNITS, NIGHT LOAD

produced. The figures were compiled covering each of the six periods into which the year had been divided and then referred to an hourly basis for both the day and the night loads. These data were then plotted, and the

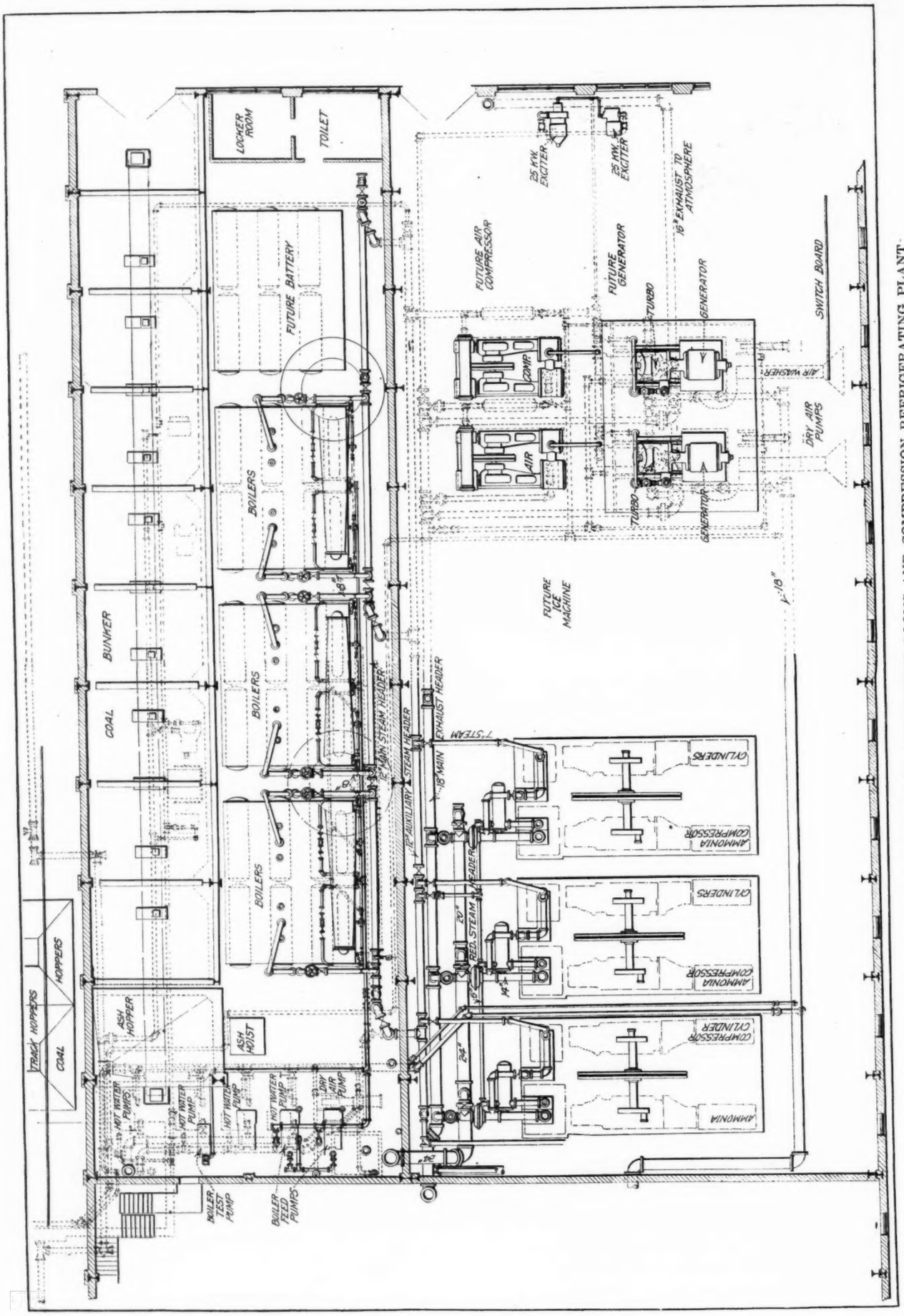


FIG. 9. GENERAL PLAN OF BOILER AND ENGINE ROOMS AND COMPRESSION REFRIGERATING PLANT

results of the analyses are shown in Figs. 1, 2, 5, 6, 7 and 8.

Figs. 1 and 2 show the estimated amounts of exhaust steam required, the exhaust produced and the balance between the two for the day and night loads, respectively, exclusive of the generating units. The day curve covers conditions between 7 a. m. and 5:30 p. m., and the night period continues from 5:30 p. m. to 7 a. m. These curves show a deficiency in exhaust steam during the greater part of the year. To relieve this situation, the mixed-pressure extraction turbines were installed. Figs. 5 and 6 show how the deficiency of exhaust steam was reduced by bleeding steam from the turbines when required. The electric power load had been estimated previously from load curves taken during three months' operation at Omaha. The steam consumption of the power units was figured on a low-pressure steam-consumption basis, when the deficiency of the exhaust steam could not be taken care of by the turbine operating partly as an extraction machine and partly as a condensing unit. The conditions were analyzed, and a division was made between live and exhaust steam. The different conditions under which the power unit would have to operate are indicated in Figs. 7 and 8. It will be evident that at times the machine will operate as an extraction turbine, sometimes as a condensing unit and at other times as a low-pressure turbine or as a combination unit using both high- and low-pressure steam.

In the plant two of these turbo-generators have been installed, each rated at 750 kw. and designed to deliver 440-volt three-phase 60-cycle currents. The speed is 3600 r.p.m., and separate excitation is supplied by either one of two turbine-driven 25-kw. exciters. Ordinarily, one of the main units is expected to carry the electric load.

The turbine is a three-stage machine with two rows of moving buckets in the first stage and one in each of the other two stages. Steam is extracted from the first stage after it has passed through the moving buckets or, if the operation is reversed, flows from the exhaust line into the turbine through the same passage and with the high-pressure steam enters the second stage through a diaphragm valve. The latter consists of a flat disk or nozzle plate with a number of different-sized openings. Through a ratchet and a series of levers leading to an isochronous governor the covering disk or valve proper is revolved to uncover or close the various openings in the nozzle plate in accordance with the pressure in the exhaust line. Simultaneously, the same governor regulates the flow through the high-pressure steam valve of the turbine. It is thus evident that when the pressure in the exhaust line exceeds 5 lb., the valve admitting high-pressure steam to the turbine tends to close and the surplus in the exhaust line flows into the turbine. When the pressure in the exhaust line drops below 5 lb., the operation is reversed and steam is bled from the turbine. All this takes place automatically so that within the limits of the turbines there is no difficulty in maintaining an exhaust balance. From the turbine the steam enters a jet condenser, and the heat in the mixture of condensation and cooling water is conserved by conducting the condenser discharge to the hotwell for boiler use or to a sump supplying domestic hot water for the packing house.

On the electrical side economy was effected by the judicious use of synchronous motors. The connected load consisted of 3000 hp. in three-phase 60-cycle 440-volt motors of the slip-ring and plain induction types varying in size from 3 to 50 hp. Depending upon how these various motors were loaded, an average power fac-

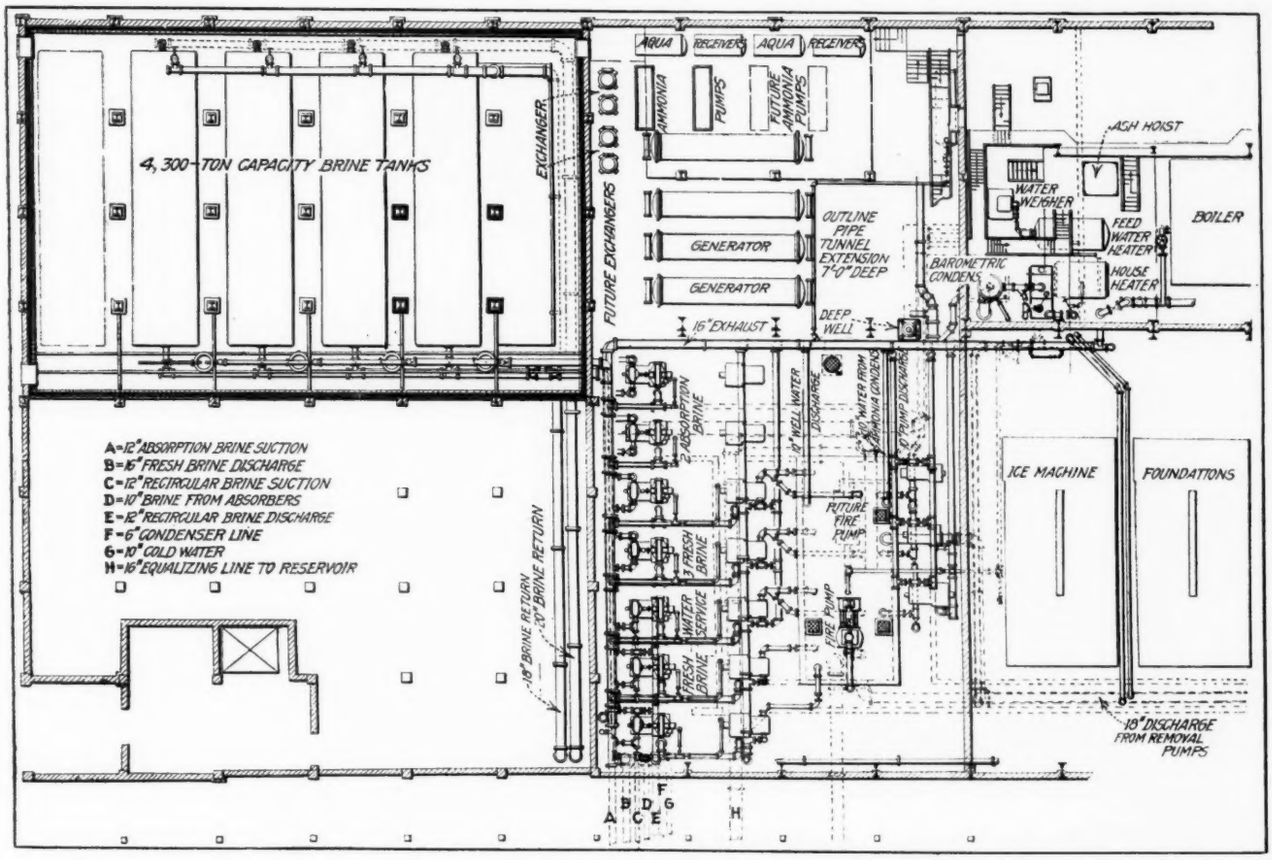


FIG. 10. PLAN OF PUMP AND BRINE ROOMS AND ABSORPTION REFRIGERATING PLANT

FIG. 9. GENERAL PLAN OF BOILER AND ENGINE ROOMS AND

tor higher than 65 to 70 per cent. could not be expected. Four large motors were needed—three to drive deep-well pumps of 2000 gal. per min. capacity each and the other, machinery in the fertilizer plant. As the entire supply of water for the plant was to be obtained from wells and there would be need for continuous service, sturdy and efficient motors were desired and in addition the question of power factor correction had a bearing. To drive the pumps, which were single-stage operating against a total head of 95 ft., three 150-hp. 2300-volt three-phase vertical self-starting self-synchronizing synchronous motors with direct-connected exciters were selected and a 115-hp. motor of the same type for the fertilizer plant. The speeds are 1200 and 900 r.p.m., respectively. The pumps were over-motored, the actual horsepower required in each case being 75 to 80. The remainder of the synchronous-motor capacity was to be utilized to raise the power factor of the system to an estimated resultant of 91 per cent. In addition to power-factor correction a careful checking up of the efficiency of these large motors as compared with that of induction motors of the proper size to handle the mechanical load showed an advantage in their favor so decided as to warrant the extra expenditure. The motors are sturdy, have a comparatively large air gap, and owing to direct connection to the pumps and exciters, are self-contained units independent of any other apparatus.

A brief review of the other departments of the plant will give some idea of the size of equipment and the general layout, which is shown specifically in Figs. 9 and 10. To supply compressed air for general packing-house use and also for requirements in the power house, two duplex horizontal air compressors each having a capacity of 1531 cu.ft. per min. were installed. The air is compressed to 80 lb. pressure, and the steam from the compressor cylinders is discharged directly to the 5-lb. exhaust line for general use.

High-temperature cold storage in which the temperature of the rooms ranges from 30 to 50 deg. is taken care of by the compression system, consisting of three 400-ton duplex, opposed, double-acting compressors driven by cross-compound steam cylinders. These machines cool 6,040,000 cu.ft. of refrigerating space containing 250,000 lin. ft. of 2-in. pipe through which brine is circulated at temperatures of about 25 deg. Of this space 20,000 cu.ft. is cooled by return brine from the freezers. For normal service two of the compressors will be required and the third held as a reserve. The three machines are served by a barometric condenser having a capacity to condense 36,000 lb. of steam per hour. It is expected that the condenser will be in use only at infrequent intervals and that for the greater part of the year the compressors will exhaust directly into the 5-lb. exhaust line.

For the sharp freezers, in which temperatures of 0 to 15 deg. are maintained, cooling is also effected by brine circulation, the refrigeration being produced by two 150-ton absorption units. The auxiliaries are turbine-driven centrifugal pumps, exhausting into the 5-lb. line from which steam is taken directly to supply the needs of the absorption plant. These two units serve 698,000

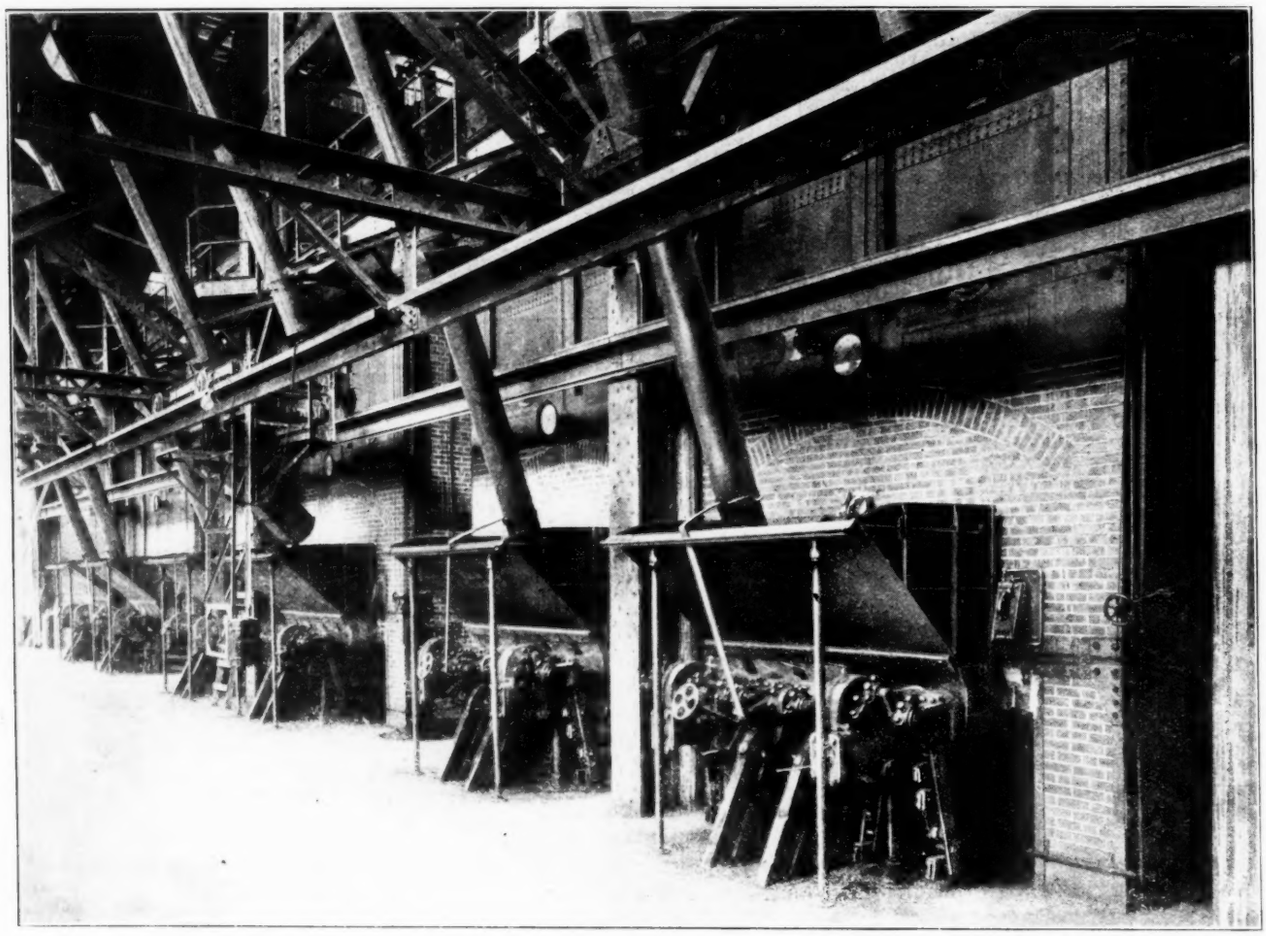


FIG. 11. BOILER FRONTS SHOWING UNDERFEED STOKERS AND TRAVELING WEIGHING LARRY

cu.ft. of refrigerating space containing 150,000 lin.ft. of 2-in. pipe for brine circulation, also a chill-water cooling tank for oleo fat and crystallizing water for butterine. For the higher-temperature system there are four steel brine tanks 50 ft. long, 11 ft. wide and 15 ft. 6 in. deep, each containing 20 flat coils, 44 ft. long, of 1¼-in. pipe. Shell-type coolers are provided for the low-temperature work. Condensers for the absorption system are of the double-pipe type, and atmospheric condensers are provided for the compression system. Cooling water is obtained from the sump, which will receive mention later, and is returned to the hotwell for further use, the surplus, if any, being wasted to the sewer.

In the boiler rooms there are installed six 502-hp. boilers of the Stirling type arranged in batteries of two, with space for another battery of boilers and plenty of room for extension of the building in the future. The additional battery is to be installed shortly, making a total of eight boilers, which will be served by two radial brick stacks 9 ft. diameter by 185 ft. high. Thus four boilers are connected to each stack, and its location is midway between the two batteries served. The operating pressure is 150-lb. gage and the superheat 50 deg. F.

Anticipating variable loads and high peaks frequently throughout the day and sometimes all day, as compared to other days, it was decided to install underfeed stokers. Normally, the boilers are to be operated at 75 to 100 per cent. overload. High capacity and high efficiency were the influencing factors, and with the fuel that will be burned, either Illinois or Youghiogheny bituminous coal, no particular difficulty is anticipated, as inferior fuels have been burned in the Omaha plant in stokers of the same type. The stokers under consideration have an equivalent grate area of 99 sq.ft., giving a ratio to the steam-making surface of practically 1 to 51. They are installed in standard settings with no arch in the combustion chamber. Owing to the character of the coal hand-operated dump plates rather than clinker grinders are provided.

Forced draft is furnished to the stokers by two turbine-driven fans each having capacity to supply six boilers at 25 per cent. overload. The fans discharge into a duct running the full length of the boiler installation, which is provided with a damper at the middle, so that the service may be divided between the two fans, or with the damper open one fan may fill the requirements. Dampers are also provided in the branch ducts to each stoker. Pressure regulation controls the quantity of air to each boiler. The vertical engines, connected to the stokers through a lineshaft and chain drives, are under hand control.

Coal for the boiler room is dumped into a track hopper from railway cars. It is transferred to a crusher by an apron conveyor and is then conveyed to an overhead bunker by a continuous bucket carrier. The bunker, which is of the continuous steel type with parabolic bottom, is partitioned off for each battery of boilers. The capacity is about 400 tons. A traveling weigh larry, electrically driven, is interposed between the bunker and the stoker hoppers.

On account of the low elevation of the site and the presence of water it was impossible to excavate deep enough to provide for a suitable type of ash-handling equipment. An ordinary hand cart is used to transfer the ashes from the hoppers under the stokers to a skip-hoist which raises the ashes to an overhead concrete bunker, and through an under-cut gate and spout they are discharged into railway cars.

In all packing plants the water supply is of prime importance. As constant supply in large quantities is needed, the pumping equipment must be substantial to withstand the service and should be highly economical. Although the plant is located on the bank of the Mississippi River, the water is so contaminated by sewage

PRINCIPAL EQUIPMENT OF ARMOUR & COMPANY'S PLANT, SOUTH ST. PAUL, MINN.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
6	Boilers	Stirling	502-h.p.	Generate steam	150 lb. pressure 50 deg. superheat	Babcock & Wilcox Co.
6	Stokers	Underfeed	99-sq.ft.	Serve boilers	Forced draft	American Engineering Co.
2	Fans	Horizontal	No. 7	Forced draft	Driven by turbines	Buffalo Forge Co.
2	Chimneys	Radial brick	9x185-ft.	Draft		Custodis
2	Turbo-Generators	A. C. 3-phase	50-kw.	Power generating units	3600 r. p. m. 2300 volts 60 cycles. 5 and 150 lb. Mixed pressure	General Electric Co.
3	Ammonia Compressors	Duplex opposed double-acting	400-ton	Refrigeration	Steam cross-compound	Vilter Manufacturing Co.
2	Absorption ice machines	Absorption	150-ton	Refrigeration	Exhaust steam	Carbondale Machine Co.
2	Air compressors	Duplex horizontal	1531-cu. ft. per min.	General purposes	Steam, heavy-duty	Ingersoll-Rand
1	Pump	Hor. centrifugal.	4200-g.p.m.	Sewage disposal	Motor-driven	Worthington
3	Pumps	Vert. centrifugal.	2000-g.p.m.	Deep-well circulation	Motor-driven	American Well Works
1	Pump	Hor. centrifugal..	1500-g.p.m.	Water circulation	Motor-driven	Union Steam Pump Co.
5	Pumps	Hor. centrifugal..	1500-g.p.m.	Brine circulation	Turbine-driven	Hill Pump Co.
6	Pumps	Hor. centrifugal..	1500-g.p.m.	Water circulation	Turbine-driven	Hill Pump Co.
2	Pumps	Hor. centrifugal..	1500-g.p.m.	Water circulation	Turbine-driven	Hill Pump Co.
1	Pump	Hor. centrifugal..	1500-g.p.m.	Circulation	Turbine-driven	Hill Pump Co.
4	Pumjs	Hor. centrifugal..	550-g.p.m.	Hot-water circulation	Turbine-driven	Hill Pump Co.
2	Pumps	Centrifugal	500-g.p.m.	Boiler feed	Turbine-driven, three-stage	Cameron
1	Pump	Hor. centrifugal..	400-g.p.m.	Water circulation	Turbine-driven	Hill Pump Co.
1	Pump	Duplex	20x12x16-in.	Fire	Steam, 1500 g.p.m.	Worthington
1	Pump	Hor. centrifugal..	10-in.	Sewage disposal	Steam, Engine 9x9-in.	Morris Machine Works
2	Pumps	Hor. centrifugal..	12-in.	Sewage disposal	Steam, Engine 12x10-in.	Morris Machine Works
1	Pump	Duplex	8x5x12-in.	Boiler test		Dean
1	Heater	Open	200,000 lb. per hr. to 220 deg. F.	Feed water	Exhaust steam	Hoppes
1	Heater	Open	210,000 lb. per hr. from 50 deg. F. to 220 deg. F.	House water	Exhaust steam	Vater
4	Brine tanks	Steel	50 x 11 x 15.5 feet deep with 20 flat coils 1¼-in. x 44 ft. long	Brine cooling		Armour Mechanical Co.
1	Condenser	Atmospheric	113x24x20ftx2 in.	Refrigeration		Vilter Manufacturing Co.
1	Condenser	Double-pipe	20x5x20ftx2 & 3 in	Refrigeration		Carbondale Machine Co.
2	Condensers	Jet	17,000-lb. per hr.	Steam		Alberger Pump & Condenser Co.
1	Condenser	Barometric	36,000-lb. per hr.	Steam		Alberger Pump & Condenser Co.
1	Conveyor	Apron and bucket	67-tons per hr.	Coal from track hopper to conveyor	Motor-driven	Jeffrey Manufacturing Co.
1	Coal crusher	30x30 in.	67-tons per hr.	Crush coal	Motor-driven	Jeffrey Manufacturing Co.
1	Weigh larry	Traveling	2000 lb.	Weigh coal	Motor-driven	Phillips Lang
1	Skip hoist	Bucket	18-ton	Ash-handling equipment	Motor-driven	R. H. Beaumont
250	Motors	Induction	3-to 50-hp.	General		General Electric Co.
4	Motors	Synchronous	115-and 150-hp.	Drive deep-well pumps and fertilizer plant		Electric Machinery Co.

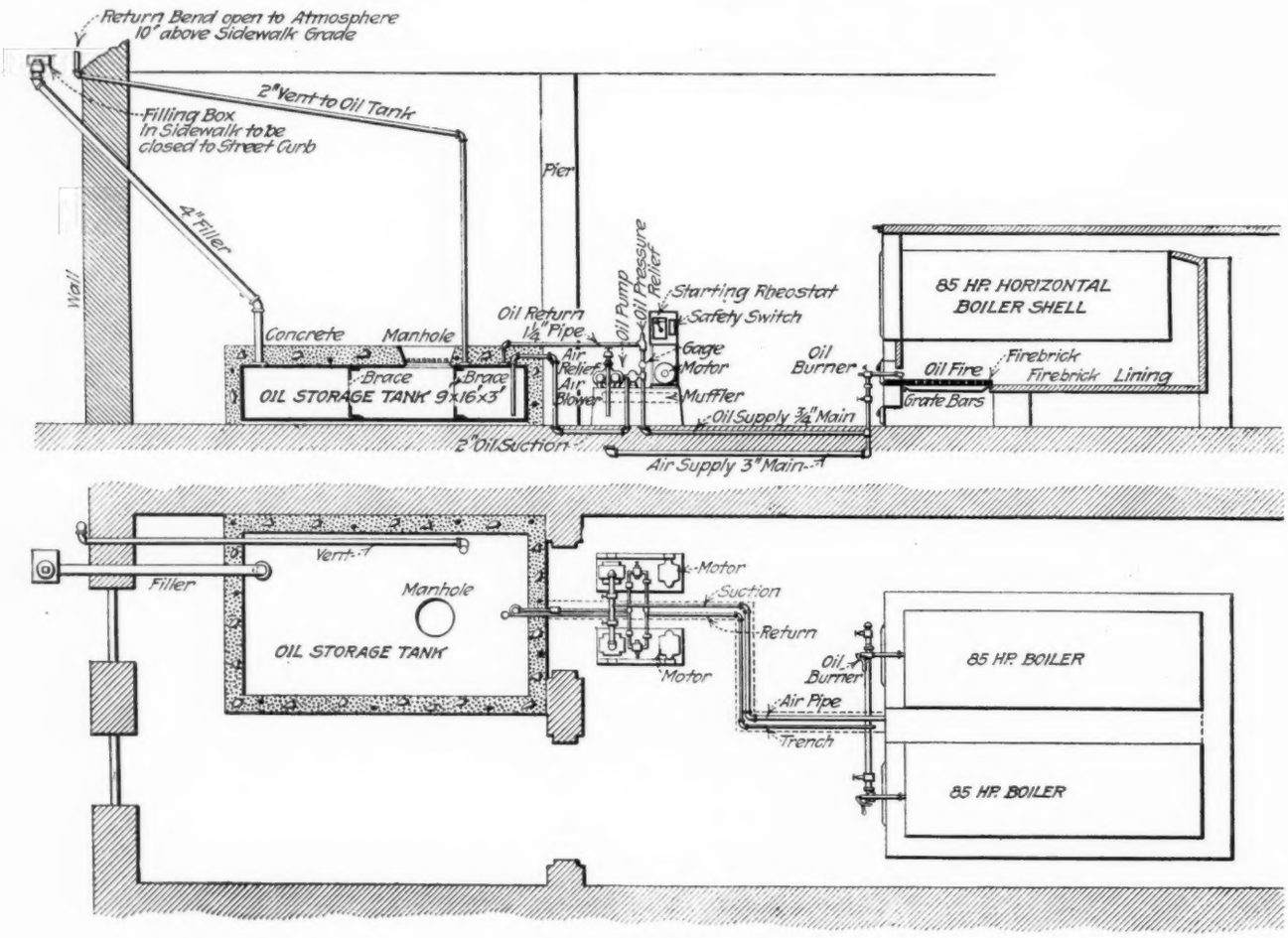
that it is not fit for use in the packing plant or for boiler feed. As a consequence, the water supply is all drawn from the three wells previously mentioned, and is discharged into a large concrete cistern. From the cistern the water through pipe connections seeks its own level in a sump provided under the pumproom. This sump is divided into two sections, one being devoted entirely to fire service and the other to the supply of domestic water and boiler feed. There are three 24-in. lines between the cistern and the two sections of the sump. One leads to the section for fire service, another leads directly from the cistern to the other section, and the third leads from the cistern to the jet condensers serving the main turbo-generators. The condensers, however, may be bypassed and the water in the third line flow directly to the sump. A certain amount of the returns from various sources comes back to the division of the sump used for general purposes, so that the temperature ranges from 56 to 70 deg. Other returns go back directly to the feed-water heater and a certain amount to the hotwell. The latter also receives the cooling water from the barometric condenser serving the ammonia compressors.

From either of these sources the water is pumped under float control to either one of two large open feed-water heaters, one designed for house purposes and the other for boiler feed, although the two are cross-connected and can be used for either service. As water at 110 deg. F. is hot enough for most purposes throughout the packing house, with a maximum of 150 deg. for specific cases, each heater is provided with an attemperatur. Water from the heater which may be at a temperature of, say, 208 deg., enters the attemperatur, and by means of a thermostatic valve the proper amount of cold water is allowed to mix with the hotter water to give the desired temperature.

For boiler feed, water from the heater passes through a venturi meter into turbine-driven centrifugal pumps supplying the boilers. In case of necessity water can be drawn directly from the sump or the hotwell, and if the pumps should fail, high-pressure steam injectors are provided for emergency use. For testing purposes a weigh-meter and reciprocating pump are installed. Outside of the fire pump this is the only reciprocating pump in the plant.

The new packing plant is about ready for operation and should prove most economical in the generation and use of steam. All the engineering was done by the motive-power department of the company, of which A. McKenzie is superintendent.

The illustration at the bottom of this page, showing the concrete oil tank and oil-burning equipment of the Burnet Street School, Newark, N. J., will interest many *Power* readers who are considering oil fuel for small plants. As shown, this equipment supplies two 85-hp. horizontal-tubular boilers; the grate bars have not been removed. Air is used for atomization in this plant, though the more general practice is to use steam. The drawing so well shows the general layout that further text explanation is unnecessary.



SECTIONAL ELEVATION AND PLAN VIEWS OF OIL STORAGE AND BURNING EQUIPMENT, BURNET STREET SCHOOL, NEWARK, N. J.

Drawing by courtesy S. T. Johnson Co., San Francisco, Calif.

Reconnecting Induction Motors—Reconnecting Problems

By A. M. DUDLEY
Designing Engineer, Westinghouse Electric and Manufacturing Company

Problems are worked out to show that any change in an induction motor's operating conditions may be considered as a voltage change.

CONSIDERATION of a simple case under each of the five characteristics of horsepower, poles, cycles, phase and voltage will bring out the manner of applying the "voltage method" to any and all changes in the motor-operating conditions.

1. Change in Voltage—A motor is connected series-star for three-phase 440 volts, as in Fig. 2. How should it be connected for 220 volts? [For convenience the table on page 725 of the issue of Nov. 27, 1917, is here reproduced.] Looking at the table and following the horizontal line "Three-phase Series Star," there appears under vertical heading "Three-phase Series Star," also, the figures "100." That is to say, the motor as it stands on 440 volts is considered 100 per cent. The new voltage is to be 220, which is 50 per cent. of 440. Hence, the same horizontal line in the table, namely, "Three-phase Series Star," is followed along until the desired figure of 50 is found, which is under the vertical heading "Three-phase 2-Parallel Star." This is the correct answer: that is, if a motor is connected three-phase series-star for operation on 440 volts, it must be connected three-phase 2-parallel star, as in Fig. 3, to operate correctly on 220 volts.

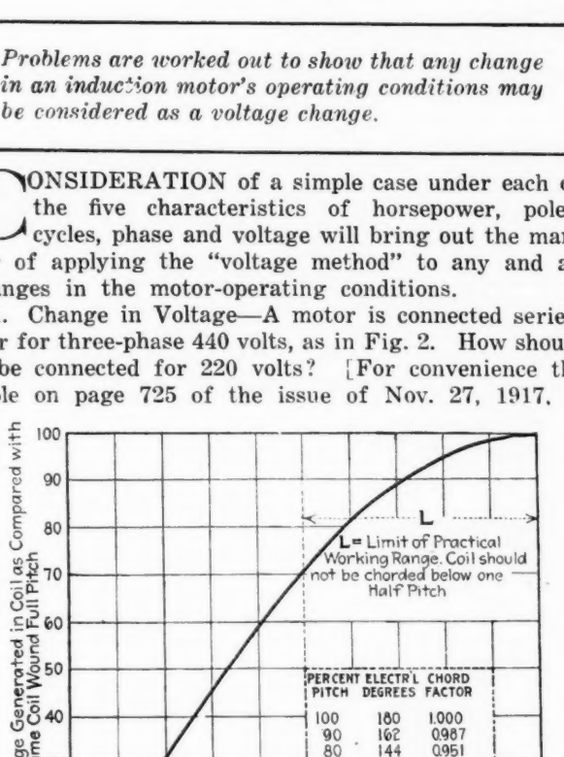

Per Cent. of Voltage Generated in Coil as Compared with Same Coil Wound Full Pitch
Per Cent. of Full Pitch
L
L= Limit of Practical Working Range. Coil should not be chorded below one Half Pitch
PER CENT PITCH
ELECTR'L DEGREES
CHORD FACTOR
100 180 1.000
90 162 0.987
80 144 0.951
70 126 0.891
60 108 0.809
50 90 0.707
40 72 0.588
30 54 0.454
20 36 0.309
10 18 0.156

FIG. 1. CURVE SHOWING THE EFFECTS OF CHORDING A COIL UPON THE VOLTAGE GENERATED

2. Change in Phase—Refer again to the table and assume that a three-phase 440-volt motor is to be reconnected for two-phase 440 volts. Inspection shows that the winding as it stands on 440 volts is four-pole three-phase series-delta, as in Fig. 4. Select the horizontal column in the table marked "Three-phase Series Delta" and follow it across, looking for a vertical column showing the value "100," since the desired two-phase voltage is the same as the present three-phase voltage, or 100 per cent. Inspection shows that there is no "100" under any two-phase connection. This indicates at once that a three-phase series-delta connected motor which is normally operated on 440 volts cannot be changed and operated on two-phase 440 volts, without rewinding. The nearest value to "100" under a two-phase column is "70," shown under "Two-phase 2-Parallel." This means that if a three-phase 440-volt motor which is connected series delta, be reconnected for 2-parallel two-phase, as in Fig. 5, it should be operated on 70 per cent. of 440, or 308 volts.

3. Change in Frequency—It is desired to operate a three-phase 440-volt 60-cycle motor on 50 cycles at the same voltage. What change should be made in the connections? Inspection indicates that as the motor stands it is connected for three-phase 5-parallel star on 60 cycles. A change in frequency should be offset by a change in voltage in the same direction and by the same amount; hence, if a motor is operated on 100 per cent. voltage on 60 cycles, it should be connected for $\frac{5}{6}$ of 100, or 83⅓ per cent., voltage on 50 cycles. However, the voltage is to remain the same on

COMPARISON OF MOTOR VOLTAGES WITH VARIOUS CONNECTIONS AND PHASES

If a motor connected originally, as shown in any horizontal column, had a normal voltage of 100, its voltage when reconnected, as indicated in any vertical column, is shown at the intersection of these two columns.

Form of Connection	Three-Phase Series Star	Three-Phase 2-Parallel Star	Three-Phase 3-Parallel Star	Three-Phase 4-Parallel Star	Three-Phase 5-Parallel Star	Three-Phase 6-Parallel Star	Three-Phase Series-Delta	Three-Phase 2-Parallel Delta	Three-Phase 3-Parallel Delta	Three-Phase 4-Parallel Delta	Three-Phase 5-Parallel Delta	Three-Phase 6-Parallel Delta	Two-Phase Series	Two-Phase 2 Parallels	Two-Phase 3 Parallels	Two-Phase 4 Parallels	Two-Phase 5-Parallels	Two-Phase 6-Parallels
Three-phase Series Star	100	50	33	25	20	17	58	29	19	15	12	10	81	41	27	20	16	14
Three-phase 2-Paralle Star	200	100	67	50	40	33	116	58	39	29	23	19	162	81	54	40	32	27
Three-phase 3-Parallel Star	300	150	100	75	60	50	173	87	58	43	35	29	243	122	81	60	48	41
Three-phase 4-Parallel Star	400	200	133	100	80	67	232	116	77	58	46	39	324	163	108	80	64	54
Three-phase 5-Parallel Star	500	250	167	125	100	83	289	144	96	72	58	48	405	203	135	100	80	68
Three-phase 6-Parallel Star	600	300	200	150	120	100	346	173	115	87	69	58	486	243	162	120	96	81
Three-phase Series Delta	173	86	58	43	35	29	100	50	33	25	20	17	140	70	47	35	28	23
Three-phase 2-Parallel Delta	346	173	115	87	69	58	200	100	67	50	40	33	280	140	94	70	56	47
Three-phase 3-Parallel Delta	519	259	173	130	104	87	300	150	100	75	60	50	420	210	141	105	84	70
Three-phase 4-Parallel Delta	692	346	231	173	138	115	400	200	133	100	80	67	560	280	188	140	112	93
Three-phase 5-Parallel Delta	865	433	288	216	173	144	500	250	167	125	100	83	700	350	233	175	140	117
Three-Phase 6-Parallel Delta	1,038	519	346	260	208	173	600	300	200	150	120	100	840	420	280	210	168	140
Two-phase Series	125	63	42	31	25	21	72	37	24	18	15	12	100	50	33	25	20	17
Two-phase 2-Parallels	250	125	84	63	50	42	144	73	49	37	29	24	200	100	67	50	40	33
Two-phase 3-Parallels	375	188	125	94	75	63	216	111	73	55	44	37	300	150	100	75	60	50
Two-phase 4-Parallels	500	250	167	125	100	84	288	148	97	73	58	49	400	200	133	100	80	67
Two-phase 5-Parallel	625	313	208	156	125	105	360	165	122	91	73	61	500	250	167	125	100	84
Two-phase 6-Parallels	750	375	250	188	150	125	433	217	144	108	87	72	600	300	200	150	120	100

per cent. is available, so the winding will have to be reconnected with $\frac{100}{83\frac{1}{3}} = 120$ per cent. of the original

the connections will have to be changed to get the effect of $\frac{550}{440} = 123$ per cent. of the old voltage. In

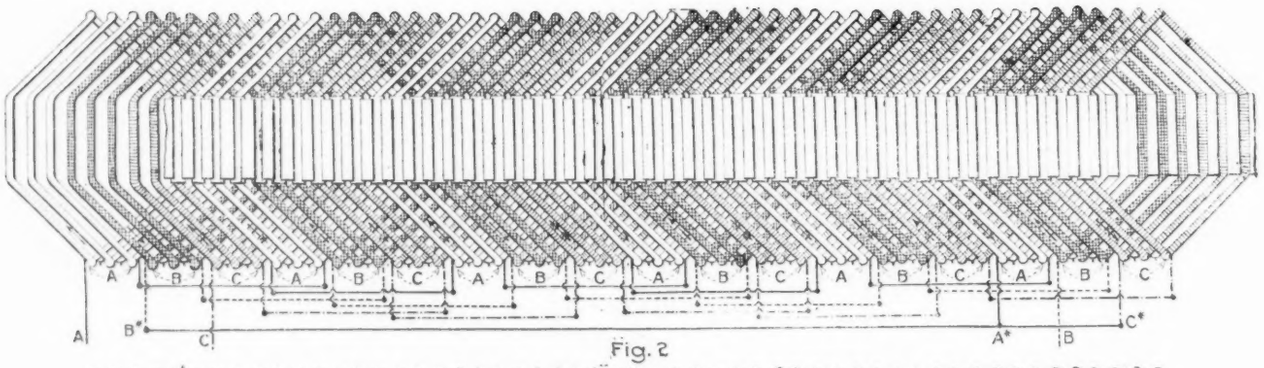


Fig. 2

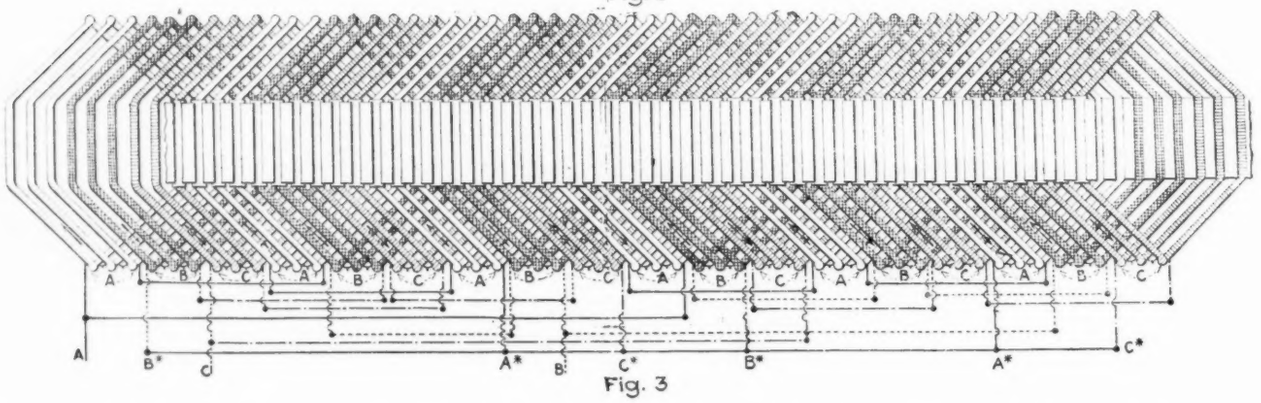


Fig. 3

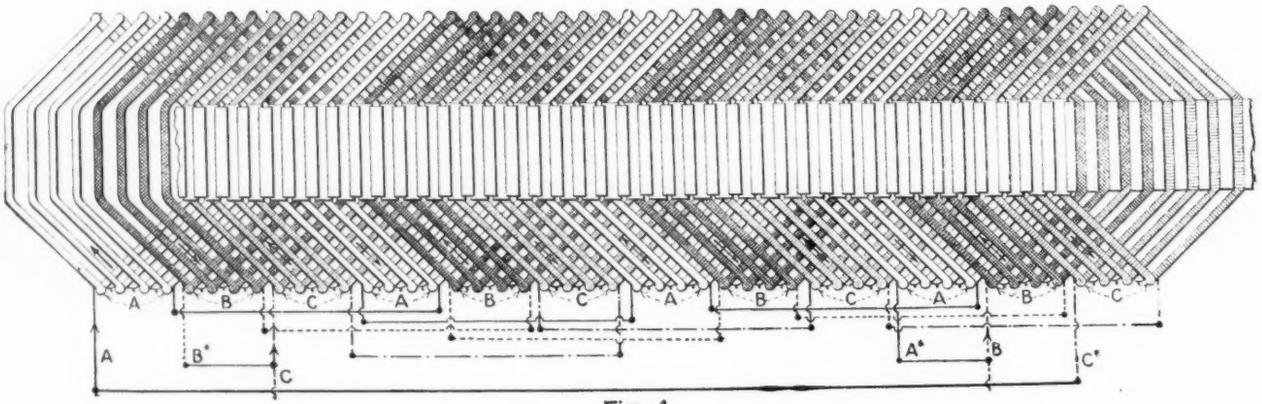


Fig. 4

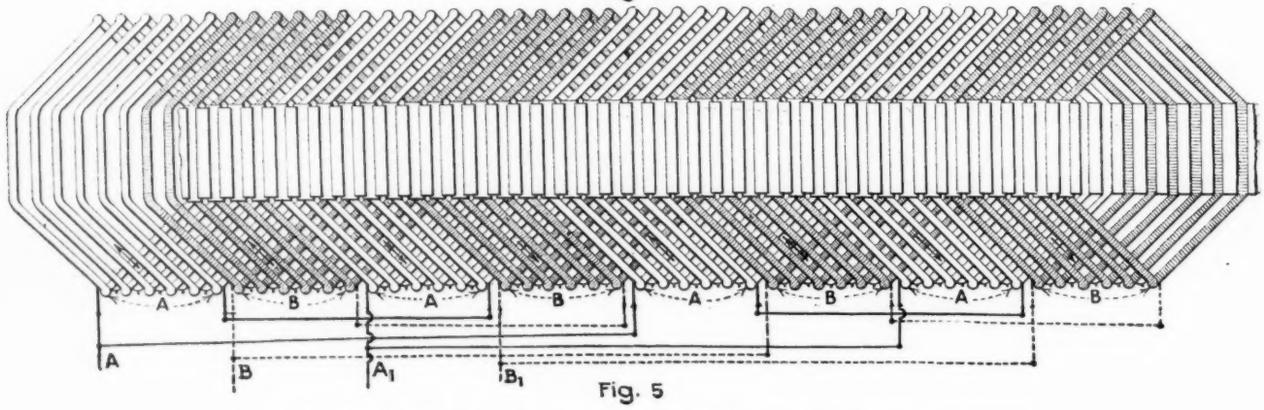


Fig. 5

FIGS. 2 TO 5. CONNECTION DIAGRAMS OF INDUCTION-MOTOR WINDINGS

50 cycles as on 60 cycles, so this result must be obtained in another way. If the voltage cannot be decreased, the number of turns in series can be increased. Another way of saying this is that we can reconnect the winding so that ordinarily it would be good for a higher voltage, and then if it is operated on the same voltage the effect will be the same as if a lower voltage had been applied to the original connection. In the case in hand the motor should, when connected on 50 cycles, be operated on 83⅓ per cent. of the 60-cycle voltage. Only 100

per cent. is available, so the winding will have to be reconnected with $\frac{100}{83\frac{1}{3}} = 120$ per cent. of the original number of turns in series. This would ordinarily mean the winding was good for 120 per cent. of the original voltage. Hence, in looking up the change in the connection table the figure "120" is located instead of 83⅓.

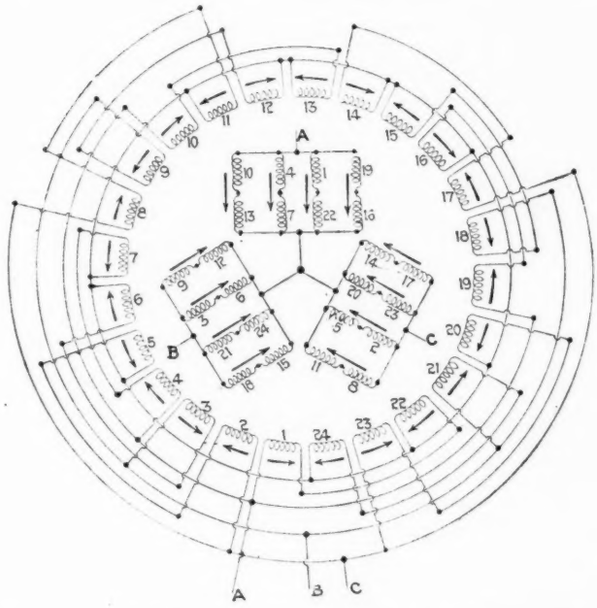


FIG. 6. EIGHT-POLE THREE-PHASE INDUCTION-MOTOR WINDING CONNECTED 4-PARALLEL STAR

Referring to the table and following the horizontal line "Three-phase 5-Parallel Star" across, search is made for the figure "120"; the nearest thing to it is "125", found under the vertical heading "4-Parallel Star." The number of poles in the motor would have to be divisible by both 4 and 5, in order to make this change possible; or, in other words, it would have had to be either 20 poles or 40 poles. As it may have been 10 poles, for example, the nearest connection that could be made would be for 144 under "Three-phase 2-Parallel Delta." This would mean the correct operating voltage on 50 cycles would be $\frac{144 \times 440}{120} = 528$ volts; or, if operated on 440 volts, it would be working under $\frac{440}{528} = 83\frac{1}{3}$ per cent. normal voltage, which would usually not be permissible on account of lowered torque and increased heating.

4. Change in Number of Poles or Speed—A 60-cycle three-phase motor is operating on 550 volts at 850 r.p.m.; it is desired to operate at 690 r.p.m. on the same voltage. What change in connections should be made, if any, in addition to changing the number of poles? Inspection shows the motor is connected 4-parallel star for 8 poles, as in Fig. 6. To get 690 r.p.m. would require to connect for 10 poles, since this would give a no-load speed of about 720 r.p.m. and a full-load speed of about 690 r.p.m. Since the motor is a generator also, it will generate only $\frac{690 \times 550}{850} = 446$ volts when connected for 10 poles and a slower speed. However, it is desired to continue at 550 volts, so that the connections will have to be changed to get the effect of $\frac{550}{446} = 123$ per cent. of the old voltage. In the table opposite the horizontal line "Three-phase 4-Parallel Star," the nearest figure to "123" is "116," which is found in the vertical column headed "Three-phase, 2-Parallel Delta." Hence, the conclusion is drawn that if an 8-pole motor, Fig. 6, is connected three-phase 4-parallel star and operated on 550 volts and it is reconnected for 10-poles 2-parallel delta, Fig. 7, it may be still operated on 550 volts, although, strictly speaking, its normal voltage would be $\frac{116 \times 550}{123} = 520$ volts. In this example no consideration was given to the fact that the throw of the coil in electrical degrees was changed in changing from 8 poles to 10 poles. This can be taken account of in the following way:

Suppose the motor as it stood had 120 stator slots and the coils lay in slots 1 and 13. Full pitch would be 1 and 16, since $\frac{120}{8} = 15$. Since the coils throw 12 slots and full pitch is 15 slots, the per cent. pitch $= \frac{12}{15} = 80$ per cent., and from Fig. 1 the chord factor for 80 per cent. pitch = 0.95. When reconnected for 10 poles, the throw of the coils is still 1 and 13, but this is now 100 per cent. pitch since $\frac{120}{10} = 12$ and 1 and 13 does span 12 slots. Therefore, when connected for 10 poles the coils are more effective in the ratio of $\frac{1.00}{0.95}$ since the chord factor for 100 per cent. pitch = 1.00 from Fig. 1. Therefore, when the change in chord

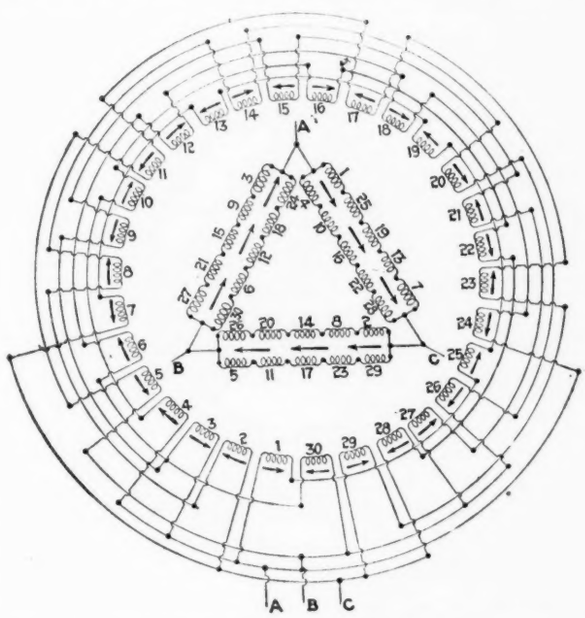


FIG. 7. TEN-POLE THREE-PHASE INDUCTION-MOTOR WINDING CONNECTED 2-PARALLEL DELTA

factor is also taken account of, the new normal operating voltage is 520, as obtained in the foregoing, multiplied by $\frac{1.00}{0.95} = 548$ volts, or almost exactly right for operation on 550 volts.

5. Change in Horsepower—A 10-hp. 220-volt motor

is operating above the allowable safe temperature, on its normal voltage, and it is found by experiment that when the voltage is raised to 250 its temperature is reduced to within safe limits. Can any change be made in the connections which will allow the motor to be operated still on 220 volts and duplicate the conditions when operating on 250 volts? An inspection of the winding shows the motor to be connected three-phase series delta, as in Fig. 4. The experiment which was made showed that the voltage should be increased to $\frac{250}{220} = 114$ per cent. of its original value. It has been pointed out that reducing the number of turns in series in a winding has the same effect as increasing the voltage on the same number of turns. In this case if the voltage was raised to 114 per cent. the same effect could be obtained by reducing the turns to $\frac{1.00}{1.14} = 87.5$ per cent. Consequently, in referring to the voltage change table, in this case, search is made for "87.5" and not "114."

Selecting, therefore, the horizontal line "Three-phase Series Delta" in the table and looking across the nearest figure to "87.5" is "86," which occurs under the vertical heading "Three-phase Parallel Star." Consequently, the conclusion is at once drawn that if a 220-volt motor has its connections changed from series-delta, Fig. 4, to parallel-star, Fig. 3, it will act in every way as though $\frac{220}{0.86} = 256$ volts had been applied to the series-delta connection. This is equivalent to increasing the horsepower of the motor, since on the original connection the motor was overloaded when carrying its rated load, but when the connections of the winding were changed the machine could drive its rated full load without distress. The reason for this is that, although the density of the magnetic flux was increased the cross-section of the copper in the winding was increased, consequently the copper losses were reduced. The latter being considerably greater than the former resulted in a reduced temperature. The capacity in horsepower has actually been increased to $\frac{256}{220} = 116$ per cent. of its original value.

From these five examples, which could be multiplied many times and from all sorts of combinations that could be made by changing the characteristics in pairs, it can be readily seen that any contemplated change can be reduced to an equivalent change in the applied voltage and the proper connection, if it is a feasible and rational change, selected from the table of phase and voltage given herewith.

(A later article will deal with a means of roughly figuring a new winding for an old core. This in turn will be followed by a description of methods for locating faults in windings.)

Treatment of Power-Plant Trouble

By M. A. SALLER

ONE OF the greatest bugaboos confronting the manufacturer and installer of power-plant equipment, as well as the purchaser or user thereof, is the "trouble case" where the apparatus does not do the work required of it, does not stand up, or in general proves unsatisfactory in operation. It is a well-known fact that very few large or small new plants are put in operation without a "trouble case" being developed in connection with some part or parts of the equipment.

Just where the difficulty will be encountered in any plant cannot usually be foreseen, for in a number of plants designed and erected by the same engineers, the operation of the equipment in the one plant will give extremely satisfactory results, but in another plant, under almost the same general conditions, a persistent trouble case will develop in connection with similar equipment.

Operator Should be Prepared to Act Promptly In Case of Trouble

The trouble case therefore cannot be anticipated either by the designer or by the operator, and consequently when difficulty does arise in connection with the operation or performance of any equipment or apparatus, steps should be taken promptly in order to study and rectify the trouble, and in practicably every case this can be done to the best advantage with the hearty coöperation of the designer, installer, operator and owner as the first essential in order to prevent a long-drawn-out controversy, because when the responsibility is shifted, and "the buck is passed," little actual progress in adjusting the difficulty can be accomplished.

A study of many power-plant troubles of various kinds points to the following as the average causes thereof: Misunderstanding of the functions of the apparatus; improper installation; improper operation or overloading of the equipment, and the mental attitude of the operators.

The first cause gives room for the development of all sorts of trouble cases. The designer or engineer may not properly or completely understand the detailed requirements of the user of the apparatus as it affects his own peculiar conditions of operation; or again, the purchaser or operator may assume, correctly or incorrectly, that the apparatus that is being installed by the engineer or the builder will do certain things that the maker does not expect or contemplate will be required of it. In other words, there is always present as a possible source of difficulty the human factor, which on one side underestimates or is ignorant of some special conditions which must be met, or on the other side expects too much or the "impossible" from the apparatus that is installed.

One method of guarding against such misunderstandings is the preparation, by the purchaser, of complete specifications as to the requirements, including all special features, and the submission by the designer or builder of equipment clear-cut statements as to the performance of the apparatus under certain conditions or under the special requirements, with guarantees and specifications as to just what he is to do; it being understood, of course, that the resort to such specifications and guarantees is not primarily for the purpose of allowing the builder or the purchaser to "get out from under," but more particularly for the purpose of de-

Secretary Lane Reviews Fuel and Power Situation

veloping the details as to what is wanted and what is to be furnished, so that both elements may finally be made to hamonize.

Frankness on the part of the purchaser as to what he really wants to accomplish, even though it does involve something out of the ordinary or difficult to attain, and frankness on the part of the engineer or equipment builder as to just what can be accomplished and done with the apparatus he proposes, and an acknowledgment that something special or more expensive is required in case conditions make necessary, are essential if the "trouble case" from this score is to be avoided.

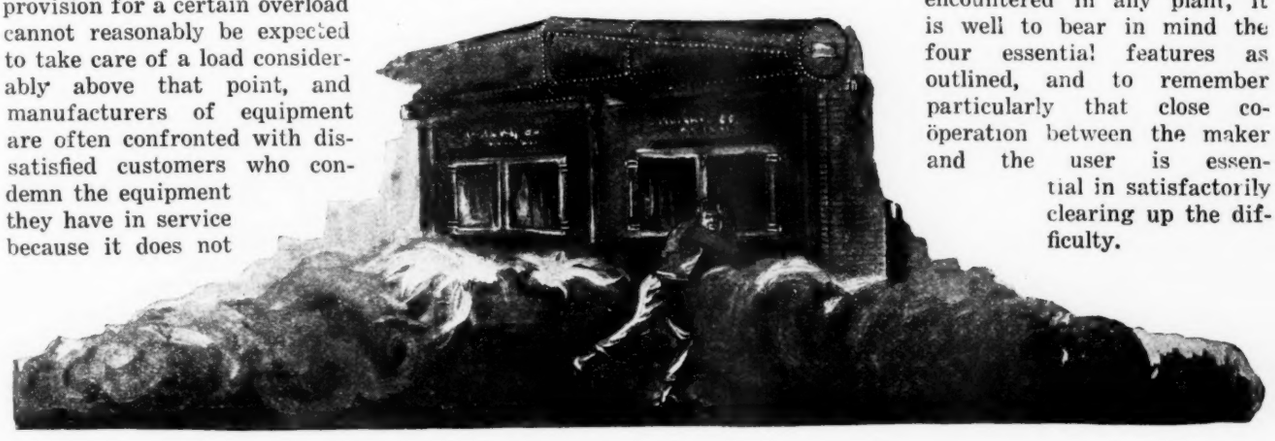
Trouble Caused by Improper Installation of Equipment

Improper installation, of course, is responsible for a larger percentage of trouble with apparatus and equipment because of faulty or inefficient operation. Practically every manufacturer of standard power-plant equipment or material has available clear and complete instructions and directions as to the proper method of installation of the apparatus he supplies, but frequently, because of incompetence or ignorance on the part of the men doing the actual installation and erection work, many important points are overlooked which may later develop to be the causes of improper operation.

Again, it is possible that the individual piece of apparatus may be installed in accordance with the maker's standard directions, but in spite of this does not fit in satisfactorily with the general scheme of the plant, which may be along some specialized line. In other words, while standard directions for installation and operation may be complied with to satisfactorily cover the general run of cases, there is always arising in engineering problems the special case which demands treatment in other than the ordinary way.

Therefore, it seems that the most desirable course to pursue is for the purchaser or installer of equipment to submit to the manufacturer blueprint or details of the manner in which the apparatus is to be installed in his particular plant, with a statement of the general operating conditions, so that the benefit of the maker's wider experience in the arrangement of equipment can be obtained.

Along the same line, trouble can also be generated because of improper operation or overloading of equipment. Apparatus that is built for a certain work with provision for a certain overload cannot reasonably be expected to take care of a load considerably above that point, and manufacturers of equipment are often confronted with dissatisfied customers who condemn the equipment they have in service because it does not operate with complete satisfaction under a tremendous overload, when the obvious course to pursue is to install additional capacity. The same condition also applies to the operating factor. Changes in engineers or the employment of incompetent operators will often he reflected in the improper operation and adjustment of equipment, which lack of attention naturally means a falling off in efficiency or capacity. Here again the operator should find it profitable to resort to the builder or installer for guidance and information for securing the best results from the installation of his particular apparatus.



Mental Attitude Is Often a Source of Trouble

Another fruitful source of trouble cases is the mental attitude of the purchaser, the manufacturer or the operating force. Not infrequently the operating engineer has a prejudice against a certain class or type or make of equipment, with the result that often he will go out of his way to condemn the operation of the apparatus or magnify any difficulties encountered in its operation. Here again is the personal element, which can only be dealt with according to the circumstances of the case.

Again, the maker or the purchaser may get it into his head that the other fellow is trying to put one over on him in the way of shifting responsibility for some troubles or difficulties, and hence instead of the close coöperation and harmony between them that is essential and desirable to insure the best service and results, they continue at loggerheads, each condemning the other and his apparatus or plant, with the result that nothing definite is done to remedy the faults and dissatisfaction prevails until the apparatus is taken out of service and junked.

This almost inevitably leads to large expense and great inconvenience for both the purchaser and the maker, all of which could easily have been avoided by a spirit of closer coöperation and a better appreciation by each of the position of the other.

The engineer is wrong when he is not open to conviction that some other design of apparatus is as well fitted for the work as is the machine he has decided is best. The manufacturer is wrong when he attempts to sell a machine that is not adapted to the work or has features that are objectionable to the engineer. The purchaser is wrong when he is suspicious of everyone concerned.

Therefore, when a trouble case with equipment is encountered in any plant, it is well to bear in mind the four essential features as outlined, and to remember particularly that close coöperation between the maker and the user is essential in satisfactorily clearing up the difficulty.

Secretary Lane Reviews Fuel and Power Situation

Believes We Have Too Many Mines and Miners for Domestic Demands, and That We Should Cultivate a Greater Foreign Market

In his annual report to the President, Secretary Lane expresses the belief that the measure of a people's industrial capacity is fixed by the power possibilities and that America may well take stock of her own power possibilities and concern herself more actively with their development and wisest use. Excerpts from his report follow.

THE strike has brought concretely before us the disturbing fact that modern society is so involved that we live virtually by unanimous consent. Let less than one-half of one per cent. of our population quit their work of digging coal, and we are threatened with the combined horrors of pestilence and famine. There was an immediate demand for facts as to how much coal is normally mined in this country; by whom it is mined; its quality; to what uses it is put; what better methods have been developed for using coal than those of ancient custom; who is to blame that so small a supply is on the surface; why we should live from day to day in so vital a matter as a fuel supply; what substitutes can be found for coal, and how quickly these can be made available.

Many of these questions we were able to answer, but if coal operators had not carried over the statistical machinery developed during the war we would have been forced to the humiliating confession that we did not know facts which at the time were of the most vital importance.

In a time of stress it is not enough to be able to say that the United States contains more than one-half of the world's known supply of coal, and that we, while only 8 per cent. of the world's population, produce annually 46 per cent. of all the coal that is taken from the ground; that 35 per cent. of the railroad traffic is coal; that in less than one hundred years we have grown in production from 100,000 to 700,000,000 tons per annum.

The Government should have a more complete knowledge of the coal and other foundation industries than can be found elsewhere, and we should not fear national stock-taking as a continuing process. The war revealed how delinquent in this regard we have been in the past. To know what we have and what we can do with it is a policy of wisdom and of lasting progress. In furtherance of such a policy the first step is to know our resources; the second, to know their availability; the third, to guard them against waste, either through ignorance or wantonness, and the fourth, to prolong their life by invention and discovery.

Next to the fertility of our soil we have no physical asset as valuable as our coal deposits. Although sometimes alarmed because those deposits nearest to the industrial centers are rapidly declining and we can already see within this century the end of the anthracite field if it is made to yield as much continuously as the present, yet it is a safe generalization that we have sufficient coal in the United States to last our people for centuries to come, but the recent strike made it clear that it is not the coal in the mountain that is of value, but that which is in the yards.

We have been content to go without insurance as to a coal reserve, because each day has brought its daily supply. There was no thought of railroads stopping or mines closing down, so that large storage facilities had not been provided, and indeed we would rebel at paying for our coal the added cost of caring for it outside its native warehouse. We have not thought in terms of apprehension, but, as always, in the calm certainty that the stream of supply would flow without ceasing.

Average for Year Low

The record year 1918, with everything to stimulate production, had an average of only 249 working days for the bituminous mines of the country. This average of the country included a minimum among the principal coal-producing states of 204 days for Arkansas and a maximum of 301 days for New Mexico. In such a state as Ohio the average working year is under 200 days. In 1917 the miners of New Mexico reached an average of 321 days, and in the larger field, the Raton field, it was actually 336 days, probably the record for steady production.

This short year in coal-mine operation is due partly to seasonal fluctuation in demand. The mines averaged only twenty-four hours a week during the spring months. The weekly report of that date showed that 80 per cent. of the lost time was due to no market, and only 15 per cent. due to labor shortage, while car shortage was a negligible factor. In contrast with this was the last week before the strike, when the average hours operated were thirty-nine and no market was a negligible item in lost time, while car shortage was by far the largest item. It follows that the short year is a source of loss to the operator, the mine worker, and a tax on the consumer.

Plants and Labor Less Productive

With substantially the same number of mines and miners working this year as last, the accumulated production for the first ten months of this year is 100,000,000 tons less than that mined in the same period last year. This 25 per cent. loss in output means that both plant and labor have been less productive, and in terms of capital and labor coal has cost the nation more than this year than last.

The public must accept responsibility for the coal industry and pay for carrying it on the year round. Mine operators and mine workers of whatever mines that are necessary to meet the needs of the country must be paid for a year's work. The shorter the working year the less coal is mined per man and per dollar invested in plant, and eventually the higher priced must be the coal. It is obvious that the 236 tons of coal mined by the average British miner last year could not be as cheap per ton as the 943 tons mined by the average American mine worker, backed up as he was with more efficient plant equipment.

Have We Too Many Mines and Miners?

The problem of the miner and his industry may be stated in another way. We consume all the coal we produce. We produce it with labor that, upon social and economic grounds, works, as a rule, too few days in the year. We therefore must have a longer miners' year and fewer miners, or a longer miners' year and additional markets. One or the other is inevitable, unless

we are to carry on the industry as a whole as an emergency industry, holding men ready for work when they are not needed in order that they may be ready for duty when the need arises. There are too many mines to keep all the miners employed all the time or to give them a reasonable year's work. This conclusion is based on the assumption that we now produce only enough coal from all the mines to meet the country's demands, which is the fact. More coal produced would not sell more coal, but more coal demanded would result in greater coal production. With the full demand met by men working two-thirds or less of the time in the year, there cannot be a longer year given to all of the miners without more demands for coal. Therefore, the miners must remain working but part time, as now, or fewer miners must work more days, or markets must be found for more coal, and thus all the miners given a longer year. If we worked all our miners in all of the mines a reasonable year, we would have a great overproduction, and to have all our mines worked a longer period means that we must find some place in which to sell more coal, either at home or abroad.

Present Methods Uneconomical

One naturally asks why the long haul over mountains and through tunnels and across bridges, and along streets and into houses by railroad, trucks and on the backs of men, when at the very pit mouth, or within the mine itself, this same coal might be transformed into electricity and by wire served into factories and homes one, two and three hundred miles from the mines? Why burden our congested railroads with this traffic? This may be a practical thing; it deserves study if coal is worth conserving.

It has been everyone's business to save coal. The railroads have experimented with some success. They get perhaps 10 per cent. of the heat energy from a ton shoveled beneath the locomotive boiler. They use one-quarter of all the coal mined. Next to labor this is the greatest expense which our railroads have. We can overlook the stoking of the domestic furnace as a national concern, for the amount of coal used in this way amounts to not more than 17 per cent. of the national coal bill, and this whole charge could be saved, it is estimated, by giving care to the bulk of our coal which is burned under boilers to make steam.

The Government should sample and certify coal. We do this as to wheat and meat, and it should be just as necessary to avoid injustice in the case of coal. The public should know the kind of coal it is buying. There need be no prohibition against the mining or selling of any coal, but coal should sell in terms of its capacity to deliver heat.

Boiler-Room Instruments Should Be Provided

It is not essential for the plant manager to be a fuel expert, but he should be familiar with the instruments that give a check on the daily operations. It is a mistake not to provide proper instruments, for they guide the firemen and show the management what has taken place daily. Instruments provided for the boiler room manifest the interest taken by the management toward conserving fuel. It indicates coöperation and encourages the firemen to work harder to increase efficiency.

It has been said that we have too many mines in operation, as we appear to have too many miners, if we are to maintain only our present output. Rapid expansion in the development of industry may justify the existence of such mines and so large a corps of workers. If, however, this should not be so, there is a foreign demand for the best of our bituminous coals, which at present we are altogether unable to meet through lack of credits on the part of those who wish the coal and lack of ships to carry it. England's annual production has fallen 100,000,000 tons, and European demand next year will be more than 150,000,000 tons above her production. As this country, prior to the war, sold abroad no more than 4,500,000 tons as against England's 77,000,000, it is quite manifest that here will be a new field for American enterprise.

Saving Coal by Saving Electricity

It is three years since Congress was urged that we should be empowered to make a study of the power possibilities of the congested industrial part of the Atlantic Seaboard, with a view to developing not only the fact that there could be effected a great saving in power and a much larger actual use secured out of that now produced, but also that new supplies could be obtained both from running water and from the conversion of coal at the mines instead of after a long rail haul. A stream of power paralleling the Atlantic coast from Richmond to Boston, a main channel into which run many minor feeding streams, and from which diverge an infinite number of small delivering lines—the whole an interlocking system that would take from the coal mine and the railroad a part of their present burden and insure the operation of street lights, street cars, elevators and essential industries in the face of railroad delinquencies—this is the dream of our engineers, and a very possible dream it seems to me. To tie together the separated power plants of ten states, so that one can give aid to the other, so that one can take the place of the other, so that all may join their power for good in any great drive that may be projected—this would be the prime purpose of the plan.

It is likely that the long-pending power bill which will make available the dam and reservoir sites on withdrawn public lands, and make feasible the financing of many projects on both navigable and unnavigable streams, will soon have become law. We shall then have an opportunity that never before has been given us to develop the hydro-electric possibilities of the country. However, as a matter of fact, the water-power resources of the country are by no means evenly distributed. Over 70 per cent. of the available water power is west of the Mississippi, whereas over 70 per cent. of the total horsepower now installed in prime movers is east of the river. Therefore, unless the East is to lose its industrial supremacy, it must press, and press hard, for the development of all water-power possibilities.

The Age of Petroleum

In 1908 the country's production of oil was 178,500,000 bbl., and there was a surplus above consumption of more than 20,000,000 bbl. available to go into storage. In 1918, ten years later, the oil wells of the United States yielded 356,000,000 bbl.—nearly twice the yield of 1908—but to meet the demands of the increased consumption more than 24,000,000 bbl. had to be drawn from storage. The annual fuel-oil consumption of the railroads alone has increased from 16⅔ to 36¼ million barrels; the annual gasoline production from 540,000,000 gal. in 1909, to 3,500,000,000 gal. in 1918. This reference to the record of the past may be taken not only as justifying the earlier appeal for Federal action, but as warranting deliberate attention to the oil problem of today. There are large bodies of public land now withdrawn, which, under the new leasing bill, which seems so near to final passage after seven years of struggle and baffled hope, will in all likelihood make a further rich contribution to the American supply.

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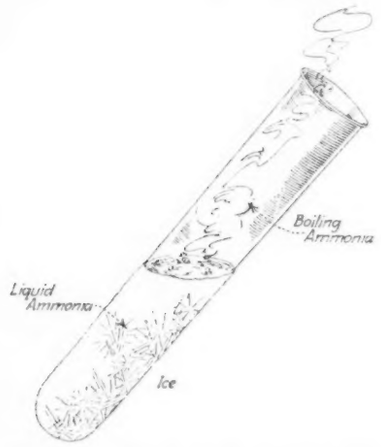

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The advantages of ammonia over those of water vapor or other refrigerants consist of the *low boiling* temperature of the substance and the reasonable pressures at which this takes place. For instance, if ammonia is allowed to boil in a glass, it will do so (at sea level) —27.2 deg. F. If it were possible to keep the pressure constant at 15.23 lb. gage and to have it boil, it would do so at zero degrees F., and at 20 lb. gage it would be 6.1 deg. F. These pressures are convenient to deal with, but, equally important, there is also the *heat capacity* of the refrigerant.

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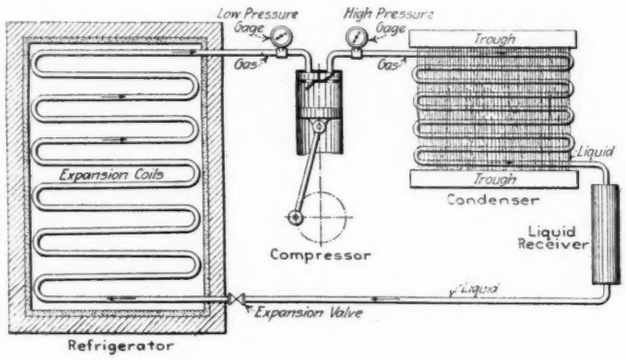

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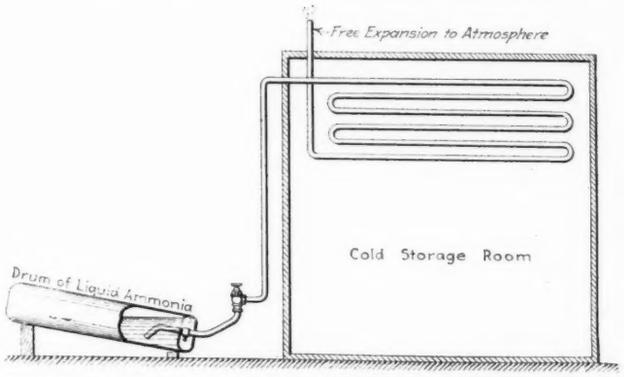

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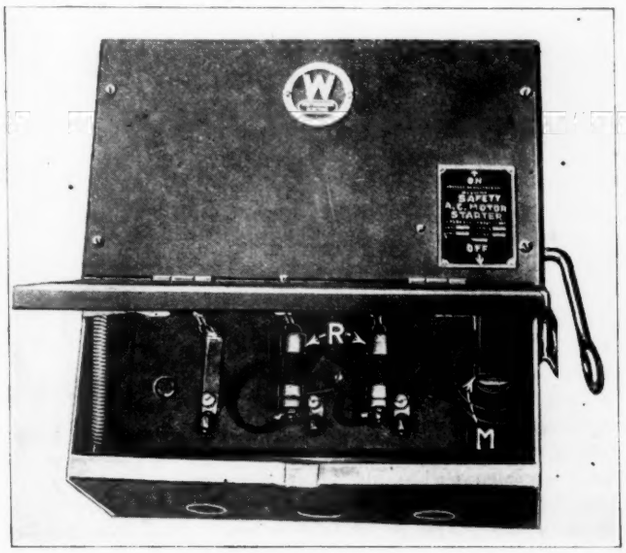

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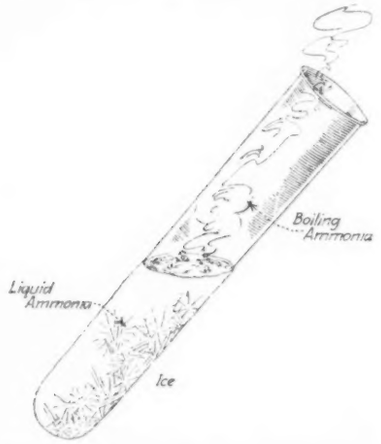

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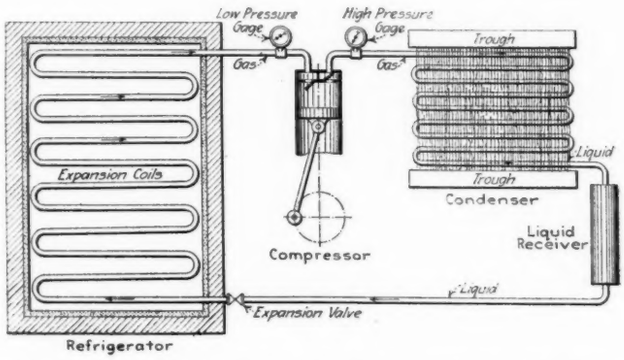

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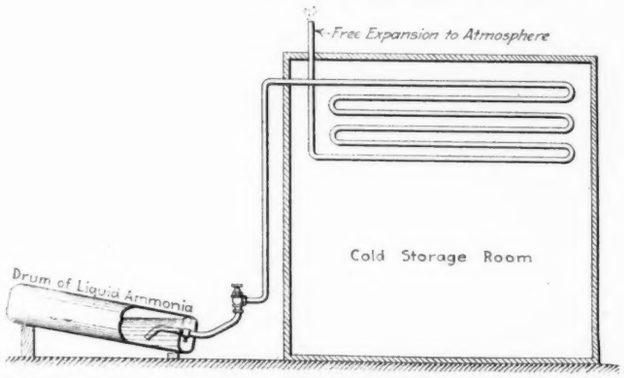

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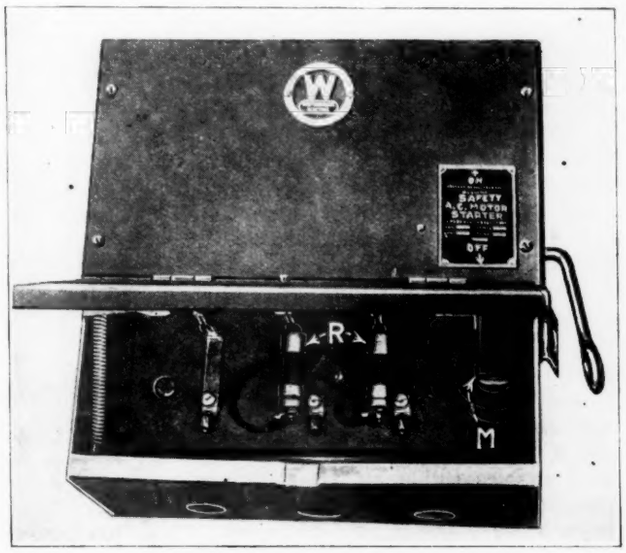

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Practical Lubrication—Oils and Their Physical Characteristics

By W. F. OSBORNE

WHAT is the best way for the engineer to select the most efficient and economical lubricants for any particular purpose? There are so many lubricants, suitable and unsuitable, that if he depends solely upon trying first one and then another until he hits upon something satisfactory, he is quite likely to find it both expensive and dangerous. If he can eliminate the unsuitable ones first and then try out a few of the suitable ones until an efficient and economical lubricant is selected, he will save many a dollar and a great deal of effort.

No matter how carefully machines are built, there is always some little difference between them. These slight mechanical differences frequently affect the lubrication, making it hard to specify a single lubricant as being the correct one to use on the machine under all operating conditions. It is therefore necessary to investigate all the factors that may have any influence on the lubricants, and by knowing what will happen when lubricants of certain characteristics are used, it is generally possible to make a fairly accurate selection. This article will explain the characteristics of the principal types of lubricants and also some of the methods that can be used in testing for them. The subsequent articles will point out the principal factors that should be looked into in picking out lubricants for the most widely used types of machinery.

American lubricating oils of mineral origin can be divided into two general classes readily distinguished by their physical characteristics—paraffin-base oils and asphaltic-base oils. There is also a mid-continent or semiparaffin crude from which oils are made possessing some of the characteristics of both of the other types. Many grades of lubricants are made from each of these crudes, and they are also frequently blended in varying percentages to obtain certain results. Lubricating oils may be of animal, vegetable or mineral origin, or combinations of any or all of them for various purposes.

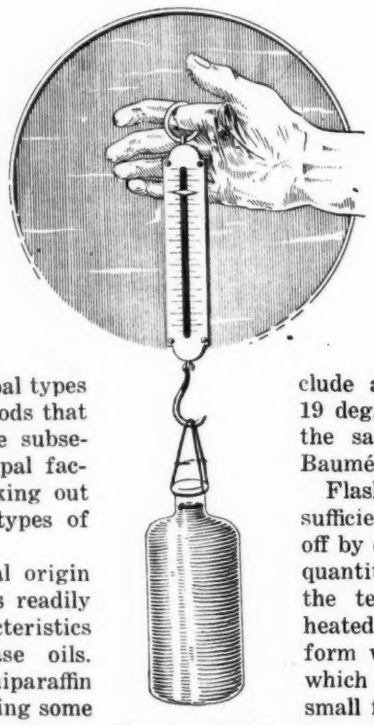

FIG. 1. WEIGHING OIL FOR THE GRAVITY TEST

Like many other materials it is practically impossible to judge from appearance alone whether an oil or grease will lubricate a machine as desired; accordingly, many attempts have been made to devise a series of chemical and physical tests to check the suitability of a lubricant before actually trying it out in the machine. The physical tests which are ordinarily made on oils are, gravity, flash, fire, pour, color, viscosity, carbon residue, emulsification, acidity.

Gravity—The specific gravity of an oil is the ratio of its weight to the weight of an equal volume of distilled water. As oils contract and expand with temperature variations, the standard of comparison is set at 60 deg. F. Specific gravities can be determined in a number of ways, but the easiest method for the engineer who has no laboratory equipment is for him to fill a clean bottle with distilled water at 60 deg. F. Weigh the full bottle and after emptying and drying it, weigh the bottle itself. Now fill the bottle to the same level with the oil to be tested heated to 60 deg. F. and weigh it (see Fig. 1). After deducting the weight of the bottle in each case, the specific gravity of the oil is found by dividing the weight of the oil by the weight of the water.

In the oil industry an arbitrary scale of gravities called the Baumé scale is used. On this scale the specific gravity of water corresponds to 10 B. and a specific gravity of 0.667 equals 80 B. To the engineer the gravity of an oil is of value only in so far as it indicates the kind of crude from which the oil was made. High-gravity oils ranging from 26 deg. B. to 32 B. are made from paraffin-base crudes, the low-gravity oils from 19 deg. to 22 deg. B. being made from asphaltic-base crudes. Excellent oils are made from both crudes for practically all purposes, and a gravity specification that would include all high-grade oils would have to read 19 deg. to 32 deg. B. Of two oils made from the same crude, the one having the higher Baumé gravity will be the thinner in body.

Flash and Fire—Any liquid on being heated sufficiently will give off vapor. The vapor given off by oil will burn when mixed with the proper quantity of air. The flash point of an oil is the temperature at which the oil on being heated slowly will give off enough vapor to form with the air over its surface a mixture which will ignite upon the introduction of a small flame and then go out. As the temperature of the oil is raised more vapor is given off, and when the production of vapor is sufficiently rapid the oil takes fire and burns continuously. This temperature of the oil is called its fire point.

A number of instruments have been made to determine flash and fire points, the most widely used being the Cleveland and Tagliabue open-cup testers. The Cleveland tester is shown in Fig. 2. The oil to be tested is placed in the cup *c* surrounded by an oil bath *b* to regulate the temperature. The heat is supplied by the gas jet *h*. The thermometer *th* shows the temperature of the oil when the flash and fire occur.

Although the flash point shows the temperature at which enough oil can be vaporized to cause a flash, it does not show how much oil will evaporate at that temperature nor does it show the temperature necessary to evaporate the remainder of the oil. It is quite possible for an oil to contain a small percentage that will evaporate at a low temperature, leaving in

the cup a much greater portion requiring a high temperature for complete vaporization. Neither do the flash and fire tests show the actual lubricating qualities of the oils, although they may point out the possible unsuitability of an oil for certain purposes where a minimum evaporation is necessary. It should be remembered that an oil will not flash or burn spontaneously at temperatures anywhere near the flash point; an actual flame or "hot spot" must be introduced from some outside source, and then there must be a sufficient amount of oxygen present for combustion.

Paraffin oils have higher flash and fire points than asphaltic oils of equal body and quality. These oils were in use many years before asphaltic oils were developed, and numbers of engineers have become accustomed to specifying a high flash on this account. There seems to be no good reason for requiring a high flash, nor are there any special objections to it provided other characteristics are suitable, as practical experience has shown that both high- and low-flash test oils are equally satisfactory for many purposes. The lower-flash oils are usually more suitable for air-compressor or internal-combustion cylinders, as they evaporate more quickly without decomposition with its resulting carbon formation.

Pour Test—All oils contract when cooled, and if the temperature is reduced low enough they will cease to flow. The lowest temperature at which an oil will flow is called its pour test. Oils made from paraffin crudes contain wax in solution and as wax alone is solid at temperatures below 110 deg. F., these oils congeal at higher temperatures than the asphaltic oils containing no paraffin wax. Asphaltic oils have pour tests below 0 deg. F.; paraffin oils have pour tests ranging from 25 deg. to 80 deg. F., although they can be lowered by a rather expensive process of chilling and filter pressing to remove the wax.

The pour test should be given due consideration when selecting oils for refrigerating equipment, motor cars in winter, railway-signal mechanisms, ring- or chain-oiled bearings or any other place where the lubricant must remain liquid at low temperatures.

Color—Outside of the laboratory the color of an oil is usually determined by looking at the light through a four-ounce sample bottle filled with the oil. Oils vary in color from water white, straw, yellow, amber and red, to dark green, brown or black. Light-colored oils are not always light-bodied, as very viscous asphaltic oils may have a pale amber color; some red or greenish oils are comparatively thin. Many pale oils are high-grade filtered oils while others are merely bleached; on the other hand, red oils are frequently filtered and when properly refined many of them are high-class lubricants. A greenish tinge to an oil usually indicates that steam-cylinder stock has been blended with a lighter oil to raise its viscosity.

The color of any oil becomes dark with use because of slight oxidization and by picking up minute particles of foreign matter. Red oils may change in characteristics just as much as the pale oils, but it is not so noticeable, owing to their darker color.

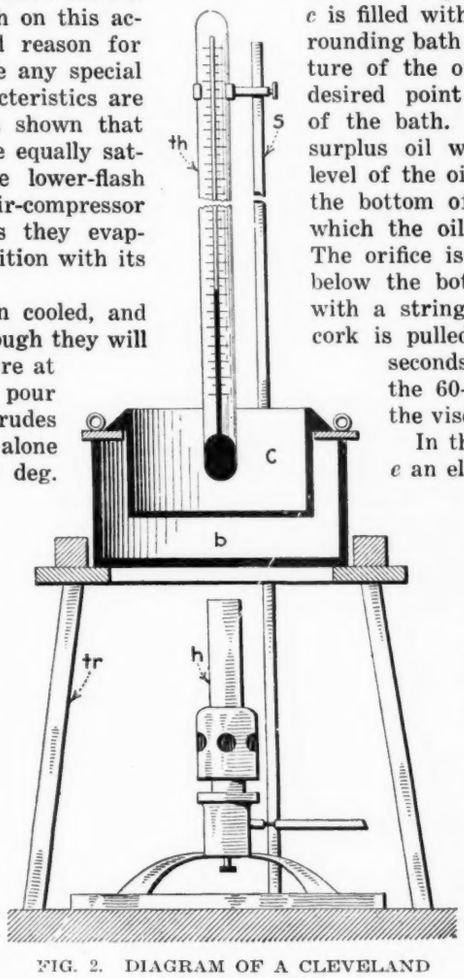

FIG. 2. DIAGRAM OF A CLEVELAND OPEN CUP TEST

Viscosity—The viscosity of an oil is the resistance offered by its molecules in sliding past one another and indicates the body or fluidity of the oil. The relative body of two oils may be compared roughly in sample bottles by turning them upside down and watching the drop from the bottoms. The oil which drops first is the thinner.

Viscosities are determined accurately by instruments known as viscosimeters, of which there are several forms. The instrument in most general use in the United States is the Universal Saybolt viscosimeter shown in Fig. 3. To make the test the cylinder *c* is filled with the oil to be tested and the surrounding bath *d* with water or oil. The temperature of the oil to be tested is brought to the desired point by regulating the temperature of the bath. The gallery *g* is emptied of all surplus oil with a pipette, thus bringing the level of the oil to a positive starting point. At the bottom of the cylinder is a jet *j* through which the oil flows into the receiving flash *f*. The orifice is inclosed by the tube *t* extending below the bottom and is closed by the cork *l* with a string attached. To start the test the cork is pulled out quickly and the number of seconds required for the oil to rise up to the 60-c.c. mark on the flash *f* indicates the viscosity.

In the illustration, *u* is a steam heater, *e* an electric heater and *r* is a gas heater, and any of these three may be used; *ss* are stirrers used to evenly circulate the heating bath.

The body, or viscosity, of any oil changes with the temperature, and a viscosity reading should always be accompanied by the temperature at which it was taken. Spindle, engine, turbine, machine, and motor oil viscosities are taken at 100 deg. F. Steam-cylinder and gear oils, because they are so viscous, are heated to 210 deg. F. before taking the viscosity reading.

The two curves in Fig 4 show how the viscosity of oil varies with a change in temperature. These two oils are high-grade turbine oils and have about the same body at the working temperatures of the bearings, 125 deg. to 150 deg. F. As the curves show, an asphaltic oil having the same viscosity as a paraffin oil at 130 deg. F. will be quite a bit thicker at ordinary temperatures. If these two oils were cooled still further, the asphaltic oil would be much the heavier until about 35 deg. F. was reached, then the paraffin oil would thicken very rapidly and congeal at 30 deg. F. while the asphaltic oil would remain liquid at temperatures below zero. When deciding upon the oil to use, the operating temperature should be determined if possible and the right viscosity at that temperature specified.

The viscosity test is most important in selecting lubricating oils for almost all purposes. If the oil is

too light in body at the working temperature to withstand the pressures, the metal surfaces will come into contact with friction and wear. On the other hand, if the oil is too heavy it may not flow to the working surfaces fast enough to maintain the oil film and wear

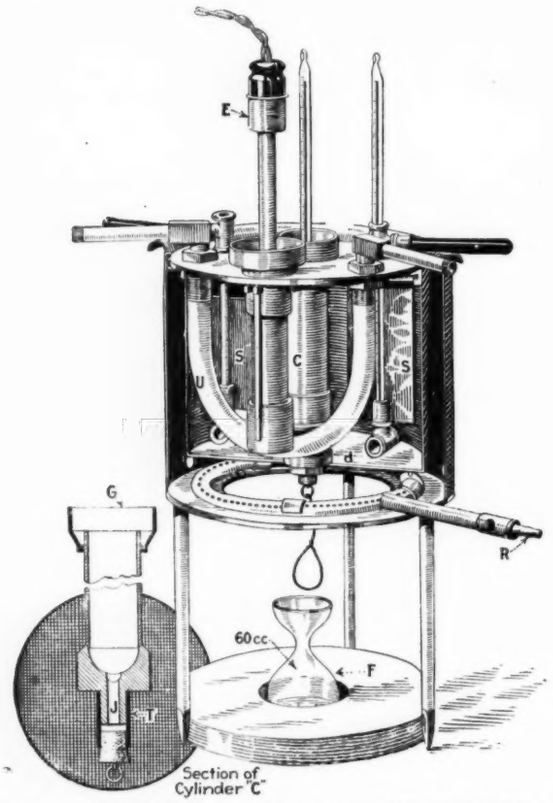

FIG. 3. SECTIONAL DIAGRAM OF THE UNIVERSAL SAYBOLT VISCOSIMETER

will result through lack of lubrication. Heavy-bodied oils also cause power losses through the internal friction of the oil itself. High-viscosity oils will sustain heavy loads and are used for slowly moving machinery; light-bodied oils are used for high-speed machines with light loads.

Carbon Residue—If oil is heated to a high temperature in the absence of a free supply of air, the greater part of the oil will distill, leaving a residue of carbon in the receptable. This carbon is formed by the partial decomposition of the oil, and the amount deposited by this test is an indication of the extent to which the oil will decompose in actual service. The oils which require the greatest heat to evaporate them usually form the largest carbon residue, as the high temperatures have a greater decomposing effect. Heavy-bodied oils leave a greater residue than lighter-bodied oils made from the same crudes with the same degree of refinement.

The carbon-residue test is helpful in selecting oils for any service where the oil is evaporated or burned, as carbon deposits, if formed, may seriously affect the operation of the machine. This applies particularly to air compressor and internal-combustion cylinders for which a low carbon residue is highly desirable. The carbon-residue test will also give some idea of the relative amount of sludge which might be formed in a steam turbine or engine oil-circulating system.

Emulsification—This test is made to show the rapidity with which oil will separate from water. Any engineer can test his steam-engine or steam-turbine oil by mixing equal parts of oil and water in a bottle and, after thoroughly shaking, observing how quickly the oil separates. The ability of any oil to separate depends principally upon its quality and the care taken in its refinement. Thin oils naturally separate more quickly than the more viscous ones, a characteristic that is taken advantage of by heating the oils in steam-engine circulating systems to improve their separation from water and dirt.

This test is valuable when selecting oils for the circulating systems of steam turbines and engines or for any purpose where there is a possibility of water getting into the oil. It will also point out the deterioration of oil with use, and if tests are made regularly it should be possible to know when a batch of oil in a system is approaching the end of its usefulness.

Acidity—A practical test to show the presence of acid can be made by coating a highly polished piece of brass with the oil and exposing it to the air for twenty-four hours. The quantity of acid in an oil can be determined accurately only in the laboratory.

All high-grade oils when new are free from acid, but they will all develop a certain amount of acidity in use. Oils containing animal or vegetable oils decompose rapidly when heated, and the acid developed is a large factor in the limited use of such lubricants. Mineral oils will also show an acid content after they have been in use for some time, due to the breaking down or decomposition of the oil. The acidity test of used oils is of value in determining when to throw away the oil in a turbine or engine oiling system and replace it with new oil. A good plan is to take samples about once a month and have the laboratory test for the amount of acid. When it is found that the acid begins to increase rather rapidly, the oil should be taken out, as there is a great possibility of its emulsifying.

All these tests taken together will usually eliminate unsuitable oils provided the service conditions under

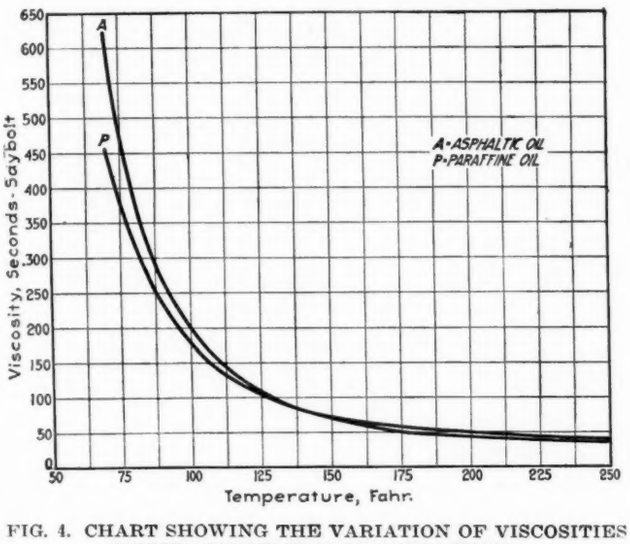

FIG. 4. CHART SHOWING THE VARIATION OF VISCOSITIES UNDER DIFFERENT TEMPERATURES

which they are expected to operate are correctly estimated. If taken singly, many of them, such as gravity, flash, fire and color, are of little value, and it is seldom wise to attempt to select an oil without knowing all of the foregoing characteristics. Few engineers outside of the larger companies have the necessary equip-

ment to make scientific tests, but with a little care and experience many of the practical tests outlined will be of considerable assistance.

Bearings are sometimes located so that they are difficult to reach or are of such design that they waste oil through leakage. In such cases a lubricant thicker than oil is more economical and requires less labor in applying. Greases are usually made by thickening a mineral oil with a soap formed by saponifying animal or vegetable oils with an alkali. They are made of varying consistencies, ranging from the thin fluid grades to extremely hard greases with high melting points. Greases of the softer grades can also be made from pure petroleum and are used where temperatures are not excessive. The melting points vary with the materials used and the method of manufacture.

All good greases are homogeneous, free from excessive alkali, acid or moisture, and contain no fillers or stiffeners of a nonlubricating nature. Some greases also contain graphite which serves to fill up the pores of the metal, making the surfaces smoother and thus reducing friction. The method of manufacture of any grease has a far greater influence upon its quality than its chemical composition.

After the poor grades have been eliminated and a number of apparently suitable lubricants have been found, the most efficient one can be determined only by a practical test under actual operating conditions. The articles to follow cover the principal points that the engineer should investigate when picking out lubricants for various types of service as well as the effect they have on certain characteristics in lubricants.

Absorption Machine Merely Needed Better Steam Circulation

BY W. EVERETT PARSONS*

Several years ago I was retained by a manufacturer of absorption refrigeration machines in a lawsuit where the purchaser of one of his machines refused to pay for the installation on its failure to fulfill the guarantee as to capacity. The machine was of the low-pressure type and was supposed to be operated by exhaust steam at 5 lb. pressure.

The purchaser (a hospital) employed several well-known experts to make tests of the refrigerating system, and they reported that the machine failed to develop the capacity guaranteed. I did not see the machine. The matter was taken to several courts and finally was tried before a referee after about two years of litigation.

The manufacturer of the refrigerating machine claimed from the first that the generator heating coils were not properly connected to the exhaust-steam supply system; that when the machine was installed instructions had been given as to how this should be done and had been ignored. The heating system and connections from the source to the generator were installed under the plans and supervision of one of the best-known heating engineers in this country. The purchaser therefore naturally concluded that the heating expert probably knew more about the heating than the refrigerating-machine manufacturer did.

At the trial before the referee there were retained on the two sides at least eight of the foremost experts in this country.

The experts for the purchaser were first to be called to testify. It soon developed that the coils of the generator of the refrigerating machine were connected on the induction system; that is, with one end of the coils connected to the exhaust main by a branch pipe and the other end to a header to which a trap and a small air-vent valve were connected. The several experts for the purchaser were asked whether the coils in the generator were likely to become airbound and how much of an opening there should be to get rid of the air. One expert for the purchaser said that a ½-in. globe valve just cracked open would be sufficient; another said a pinhole would be sufficient after the generator was in full operation. The latter expert, however, at the next sitting, asked to have the "pinhole" testimony stricken out.

At the time of the trial the writer was supervising the remodeling and enlarging of one of the largest combination power and refrigerating plants in New York, near where the trial was going on.

In the basement of this power plant there was a large horizontal Berryman feed-water heater. This heater had been originally connected so that practically all the exhaust steam from the engines and pumps entered it through a 16-in. exhaust main, and whatever was not condensed passed on to the steam condensers operated at atmospheric pressure to make distilled water for an ice-making plant. Some time before the trial began the steam condenser had been moved to another part of the basement and the steam outlet of heater had been closed with a flange for a 3-in. pipe, but bushed down to 1-in. Then a 1-in. nipple and globe valve were connected as an air vent.

The heater as connected was, of course, similar in principle and arrangement to the generator of the absorption machine. I decided to have a series of tests made with different sized air-vent openings. These tests were made while the examination of the experts was in progress. About the time this examination was completed, I handed to the lawyer for the refrigerating-machine manufacturer a copy of a table of the results of tests. From the series of tests the results of those in which all of the conditions were as nearly alike as possible excepting, of course, the temperature of the feed-water leaving the heater, were used. With the 1-in. air-vent valve wide open the results were 6.28 per cent. better than with the 1-in. valve open only one-half turn and the results obtained were 32.41 per cent. better with a 3-in. valve wide open.

With the 3-in. valve wide open some steam passed out with the air. This indicated a free circulation of steam over all the heat-absorbing surfaces, and this without a doubt helped to make the results so much better.

A free circulation of steam in the coils of the generator kept free from air is what the refrigerating-machinery manufacturers had provided for and insisted upon when the machine was installed.

The lawyer for the machine manufacturer decided to show the results of my tests to the opposing lawyer. When he did so, the case was promptly ended without taking further testimony and the machine manufacturer was promptly paid for his machine.

I might, however, add that I was informed that during the litigation the purchaser arranged with a competitor to remodel the refrigerating plant at a considerable expense, which, it would appear, was unnecessary.

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Steam From the Earth

About a year ago mention was made in *Power* of a station in Italy in which use was made of steam extracted from the earth. Ing.-Prof. Luigi Luiggi, of Rome, who has recently been in this country, has kindly furnished *Power* with the particulars of the installation.

The regions south of Volterra are rich in volcanic manifestations, among them the "soffioni," or "whisperers," of Larderello, Fig. 1, and in the neighboring communities of Castelnuoeo, Sasso, Monterodondo, Lago, Lustidnano and Serrazzano. In all these regions, extending for many square kilometers, there break out of creases in the earth jets of steam at high temperatures, superheated vapors rich in boric acid, ammonia, carbonic

FIG. 1. NATURAL STEAM JETS OF LARDERELLO

acid, hydrogen sulphide and other gases. This vapor is condensed for the extraction of boric acid and other byproducts. By suitable borings from about 8 to 16 in. in diameter, and from 300 to 500, or even 750 ft. deep, lined with suitable steel tubes, there can be obtained powerful jets of superheated steam of from 10,000 to 40,000 lb. per hour capacity, and at a pressure of from two to five atmospheres, one of which is shown in Fig. 2. These wells remain unchanged in yield and temperature for years and are not affected by the driving of other wells if the latter are not too near to them.

The first experiments in the use of this steam for power-producing purposes were made by Prince Ginori-Conti, the leader of the borax industry. By directing a jet against a bucket wheel, an ordinary motor was made to drive a little dynamo capable of supplying a few electric lamps. Encouraged by these results, in 1905 he applied the natural vapor of the soffioni to a 40-hp. motor, utilizing in this way a small part of the jet from the Venella well, which issues at a pressure of about five atmospheres, a temperature of about 330 deg. and a quantity of about 11,000 lb. per hour.

The results obtained during several years were most satisfactory from the viewpoint of the power produced, but somewhat less so with respect to the action of the steam upon the motor, on account of the sulphuric and other corrosive products accompanying the vapor.

Meanwhile new wells were constructed, larger and deeper, and jets of various powers were obtained, among others one which produced 55,000 lb. of steam per hour at a pressure of about two atmospheres absolute, representing a theoretical capacity of 4000 hp. under conditions which made 40 per cent. of the theoretical realizable. Bringing together a number of these jets would have made it possible to supply turbines of several thousand horsepower capacity. Caution led, however, to making an experiment on a moderate scale sufficient for conclusive results by means of a turbo-alternator of 300 hp. set up in 1912 for supplying lighting and current to the Larderello establishment.

The results of this experiment were so satisfactory as to induce Prince Ginori-Conti to establish a plant of larger capacity, the demand for which was made more imperative by the fuel shortage due to the war. The plans were made and carried out by Ing. Bringhenti. Three Tosi turbo-alternators of 3000 kw. each were installed, with surface condensers supplied with circulating water from cooling towers.

To avoid the chemical action of the natural vapor mixed with corrosive gases on the metallic parts of the turbine and at the same time to avoid the possibility that the noncondensable gases issuing with the vapors should make it impossible to maintain a high vacuum in the condenser, the steam was not supplied directly to the turbine, but served to heat three multi-tubular boilers working at a pressure of 1¼ atmospheres absolute, which supplied the turbine with steam from the condensation water of the turbine itself. The steam from

FIG. 2. JET FROM A BORING CONFINED IN A PIPE

the soffioni condensing, while giving off its heat to the boilers, is then utilized, as previously, for the extraction of boric acid and other secondary products. The boilers are of the vertical-tubular type with aluminum tubes, this metal being the most resistant to corrosion from the gas of the soffioni.

The three turbines can develop about 4000 hp. each. They are direct-connected to three alternators of 3000 kw., working normally at 2759 kw. capacity. They are three-phase units of ordinary type with power factor 0.7 at 4500 volts and 50 cycles. The electrical energy is transformed to 36,000 and 16,000 volts, and distributed by five separate lines to various main centers of Tuscany.

EDITORIALS

Power Supply and Generation of the Future

IT HAS been estimated that with steam at three hundred pounds and five hundred and twenty degree superheat, used in a turbine operating on twenty-nine inches of vacuum and eighty per cent. Rankine-cycle efficiency, a kilowatt-hour may be produced on eight pounds of steam. Even this condition, when it will be possible of attainment, will utilize only about twenty-five per cent. of the energy in the coal. At present steam pressures are being used and values of superheat employed that make the development of fittings for boilers and steam lines a difficult problem. The stoker has been developed to where we are getting about all that can reasonably be expected from the boilers in the way of efficiency, and turbines and generators have been built in compound units up to sixty thousand kilowatts. Even before these sizes are reached, there is comparatively little to be gained in economy by increasing the size of the machine, and machines of this capacity are applicable only to the largest systems. Looking at these facts, it is evident that the development of power-plant equipment, so far as concerns the conversion of chemical energy in the coal into mechanical energy, has apparently almost reached the practical limit.

Dr. Charles P. Steinmetz suggests that the solution of the problem may be found in installing a simple steam-turbine-driven induction generator between the high-pressure steam boiler wherever steam is used for heating, and converting a percentage of the energy into electrical power and supplying this to the power-distribution system of the community. There are many industries that use large quantities of steam in their processes, where the foregoing has been given consideration for some time past. However, a large percentage of the heating plants are in operation not over six months per year, and the size of the equipment that could be operated from them makes the proposition economically doubtful. However, this objection might be satisfactorily overcome by supplying heat to all the buildings in one city block, or a number of blocks, from the same heating plant. This scheme would allow the use of economical equipment, but even such an arrangement has its limitations. When this is done under the most favorable conditions, it is at present possible to convert not more than sixty to sixty-five per cent. of the chemical energy in the coal into heat and mechanical energy. This is a decided improvement over the best efficiency of conversion now obtained in the most economical power plants, but conditions where this is possible for over six months of the year are very limited, consequently it does not offer any very promising solution to the problem.

With the present development in the heating and power equipment, it is apparent that some very radical change must be made in steam power-plant equipment before any great improvement can be made in the efficiency of converting the chemical energy in coal into mechanical or electric power.

There are two ways in which large conservation of coal can be made; namely, the more complete development of our water powers, and the electrification of our railways. It has been estimated that the steam railways of this country burn, each year, fuel equivalent to between one hundred and forty and one hundred and fifty million tons of coal. Over two-thirds of this can be saved by electrifying our roads, which is equivalent to saving about fifteen per cent. of our present coal production. Furthermore, if our railways were electrified, much of this power would be supplied from hydro-electric stations, resulting in even a greater saving of fuel. Probably not over fifteen per cent. of the fifty million kilowatts of our total potential water power is developed, leaving some forty million kilowatts undeveloped—more than enough to supply all our power requirements at the present time. However, a considerable percentage of this is situated where it is not available, and much of that which is available cannot be utilized by our present method of concentrating of large blocks of power in a small number of plants. Dr. Steinmetz's suggestion that the small water powers be developed by the installation of small water turbines and induction generators, and tied in through simple switching equipment to the transmission system, holds wonderful possibilities, especially as such plants are already in satisfactory operation. Although the prospects are not very favorable for any epoch-making development in the efficiency of our modern power plants in the near future, the electrification of our railways and the development of our water powers, if taken full advantage of during the next twenty-five years, will make this period equal in engineering achievement to that of the past twenty-five.

Secretary Lane's Recommendations

ENGINEERS and executives should read what Secretary Lane has to say about the fuel supply and power problems of the country. Admittedly, government statistics are very incomplete in this respect and a survey of power resources would repay the nation many times the expenditure involved. With singular far-sightedness Mr. Lane has grasped the necessity of altering our present wasteful methods of hauling and utilizing coal for power purposes if we are to conserve the supply and meet the demands of the future. Further development of our water powers, the location of great power plants at the mines and greater electrification of our railroads is a program that will soon become imminent.

"We have too many mines and too many miners to meet the domestic demand," says Mr. Lane, as a result of which the mine year, even for 1918 with everything to stimulate production, averaged only two hundred and forty-nine working days. Moreover, during 1919 the production decreased by twenty-five per cent. Undoubtedly this is a factor in the present high cost of coal, because both the labor and the overhead are proportionately greater on the smaller production.

But when we have effected the purposed conservation measures through giant power plants at the mines and electrification of the railroads, the domestic de-

mand will have decreased still further and the average miner's year will have shrunk to fewer days. The remedy for this, we are told, is to cultivate a large foreign market for coal. This will undoubtedly make for increased business in the coal industry, but what about conserving our available coal supply for the future? In other words, Can we afford to live wholly in the present and let the future take care of itself, trusting to the development of ways to utilize the atomic energy which Sir Oliver Lodge has lately been discussing?

Again, the average purchaser of coal will be led to ask what assurance he is to have that the old law of supply and demand will not be invoked against him as an argument for further increases in price, if we are to cultivate a great foreign market.

But, putting aside the coal situation, which can be viewed from so many angles as to become positively confusing, it is most reassuring to read the recommendations, coming as they do from a Cabinet Officer, that the Government should adopt a definite policy of protection to all legitimate developments of oil properties by Americans in foreign countries. Oil fuel is a very live topic at present, and the problem of an adequate supply is pressing. Such action as urged by Secretary Lane should, therefore, receive immediate consideration.

Reasonable Administration of Boiler Laws

THE Massachusetts Board of Boiler Rules requires that "Each boiler shall be stamped by the builder in the presence of the inspector with a serial number and with the style of stamping shown in facsimile previously approved by this Board."

Occasionally, the representative of the builder picks up the wrong stamp or gets it upside down and the inspector does not notice it, with the result that when the boiler arrives in Massachusetts the number so stamped does not agree with that upon the certificate.

It would seem a simple matter for some member or agent of the Boiler Inspection Department in Massachusetts to correct the erroneous stamping when the chief was satisfied that an error had actually been made and that the boiler in question was really the one covered by the certificate with which the correction would make it agree as to number. The Massachusetts authorities have, however, insisted that the inspector under whose supervision the error occurred should go to Massachusetts and do the restamping himself. Under a former department head the employee of the boiler shop who did the stamping was obliged to go there, too. Inasmuch as the inspector's word and that of the employee who made the error is all that the department has to go by in case they are dragged to Boston, affidavits sent by mail ought to be equally convincing and, in connection with the bill of lading and description, ought to be sufficient to identify the boiler and warrant the official correction.

Insistence upon a personal correction by the man who made or passed the error as a punitive or deterrent measure is deplorable. To send one or two men from a distant state just to stamp a number is an economic crime. It wastes skilled labor, makes boilers cost more and serves no good purpose. Compliance by the Board of Boiler Rules with the request made at its last hearing to revise its practice in this respect would alleviate the apprehension with which business men regard the conferring upon governmental factors powers which permit them to interfere, even in a beneficent way, with private enterprise.

The Future of Refrigeration

SOME years ago we sat at a banquet of the American Society of Refrigerating Engineers in New York and heard a stirring address by Dr. C. E. Lucke, in which he expressed deep regret that there had been so little progressive development in the art of mechanical refrigeration. He took occasion to cite the forward strides in many other branches of the mechanical arts in comparison with refrigeration. With appealing emphasis he said the field for greater development was even then crying for attention. While the greater number of those present sympathized with the Doctor's views, there were some few who felt that the criticism was too sharp.

This year the society again had a banquet, and again Dr. Lucke was one of the speakers. He recalled his comments of the years before and expressed happiness that the situation was so favorably different. During the three days previous to this banquet the society had listened with profound gladness to several papers, some scientific, some descriptive of machines that marked a really great event in the art. The technical staff of the National Bureau of Standards had contributed data dealing with the properties of ammonia so sorely needed from a scientific point of view if less urgent from shop and operating viewpoints.

The Doctor saw in this meeting, as many others saw, that there was manifested a truly earnest effort for closer coöperation of the engineer and the scientist. Needless to say there must be an exercise of this spirit before the great needs of the industry are met.

Dr. Lucke sees that refrigeration is due for an epochal era. He thinks it may be here now in the form of the high-speed ammonia compressor electrically driven. Certainly, those who view the art and its potentialities in a broad yet enthusiastic way are in accord with the distinguished Doctor's views.

The American Order of Steam Engineers, through its organ, *The Popular Engineer,* voices editorially the sentiments of safe and sound unionism. Condemning the Boston police strike and the many other recent evidences of radicalism, it calls upon the engineering fraternity to come forward to assist capital and labor in understanding each other as partners in common endeavor, to the end that brains and technical training may receive just recognition in contradiction to the present tendencies towards subsidizing only those who work with their hands. It is gratifying to see such expressions from an association in a position to exert wholesome influence from within.

A bit of trouble-making legislation is proposed for the coming session of the New Jersey legislature in a bill which provides that water and electric meters shall be made so that they can be turned back to zero each time a reading is made by the corporation. The proposer evidently has no idea of the mere physical difficulties involved. If a man cannot take the reading of his meter and subtract the last month's reading from it, he will not be able to check his account if the meter starts from zero each time.

Representative Keller has introduced a resolution providing that, "as the foundation of our economic existence is endangered," the President should be instructed by Congress to take over and operate the bituminous-coal mines.

CORRESPONDENCE

Believes Purge Tank Won't Work

Having read H. J. Macintire's article on "The Refrigerated Purge Tank" in the Aug. 12 issue of *Power*, I cannot agree with his proposed method of purging foreign gases from a refrigerating system. I find his figures to be mostly correct, and if they could be put into practice a lot of ammonia that now goes out through the purge valve could be saved.

But the trouble is, if we cooled this mixture of foul gas and ammonia gas to 32 deg. F. it is likely that the same percentage of the permanent gas would condense as of the pure ammonia gas. This, of course, would depend on what this permanent gas was. This permanent gas or foul gas is often thought to be a noncondensable gas, while, in fact, all gas will liquefy if brought to the right pressure or temperature. I have found some permanent gas to be lighter and some heavier than ammonia gas.

The lighter will freely burn when emerging from the purge valve, while the heavier will not. Some of this gas (while it is not ammonia gas) will condense at about the same pressure and temperature as ammonia, but usually at a little higher pressure. This kind of gas is a source of trouble and is hard to deal with. It is undesirable because of its higher condensing temperature or pressure, which keeps the entire condensing pressure higher, and again, its latent heat of vaporization is usually not so much as that of ammonia, and its evaporating temperature is usually higher.

However, this sort of gas rarely accumulates in the ammonia system, but comes with the ammonia, consequently only the best ammonia should be used and it should be tested. The gas that does get in the system is air caused by pumping a vacuum on the system when there is a leak. The leaks are usually in the compressor-rod packing and stop-valve stem packings. Even if the system is tight and free from ammonia leaks, these packing leaks will start as the vacuum is formed, because the vacuum causes the temperature to drop 25 or 30 deg. F. on the "low" side and 75 to 100 on the "high" side, below usual working temperature. The lower temperature causes the packing to shrink and let in the air. Another "permanent" gas is generated from the compressor lubricating oil, caused by high compressor temperature, poor oil or both. With the plant temperatures I advise a discharge temperature from 150 to 220 deg. F., depending on the temperature of the brine and of the cooling water and the type of compressor.

But getting back to purging an ammonia condenser, the most practical method is to have a stop valve on both the gas inlet and liquid outlet to each stand of the ammonia condenser, likewise a purge valve for each stand. To purge, shut the gas-inlet valve to one stand of condensers, having the plant operate as usual, slow the compressor or compressors if necessary to keep the condensing pressure the same as the usual working pressure.

This stand with the gas shut off will gradually fill with liquid as the gas in it condenses. All the permanent gas will be forced to the top by the liquid coming in from the bottom. This gas can then be purged off. When the liquid reaches the purge valve, it is easily detected, as "it will smoke and stink." This stand can then be cut in and the other stands purged in a like manner. I would call Mr. Macintire's attention to the fact that cooling water at 70 deg. F. does not mean that the condensing pressure should be 114½ lb. (gage).

The pressure should correspond with the temperature of the water leaving the condenser and not with the temperature of the water going to it. But it seldom does so in practice. It usually runs 10 to 40 lb. higher unless the plant has lots of condensers or a small compressor or both. Supposing the 70-deg. water was raised in temperature to 80 deg. F. while going over the condenser. The condensing pressure would be 139.6 lb. gage instead of 114.5 lb. That makes a difference, and in Mr. Macintire's case the excess pressure would be 40.4 lb. instead of 65½ lb.

But, further, it is good practice with 160-lb. gage pressure and cooling water at 70 deg. F. And even though 180 lb. is carried, it is not necessarily permanent gas. It may be "short" water or "short" condensing surface or both. But the permanent gas is a good thing to look out for. With a good tight system charged with pure NH_3—lubricated with the proper kind of oil—and never exceeding 220 deg. F. discharge temperature and pumping to a vacuum only when necessary, and then only after all packing glands have been tightened, and if all pipe and fittings in the system are made for ammonia use, the system will require no purging. Of course, if we could have a rectifier in the system charged with something that would absorb everything but NH_3, then we would have no further trouble with foreign gas in the system if we kept the rectifier clean and adequately charged with the absorbent.

Winkelman, Ariz. GEORGE TROSPER.

Precaution Against Burns When Handling Lime

The increase in the use of boiler-water purification plants compels many engineers to handle the lime and caustic soda and other chemicals required for their operation. Ordinary care will safeguard against danger

from injury, but it has been my experience that even with careful handling the operator is constantly open to the danger resulting from the chemicals spattering into the operator's eyes.

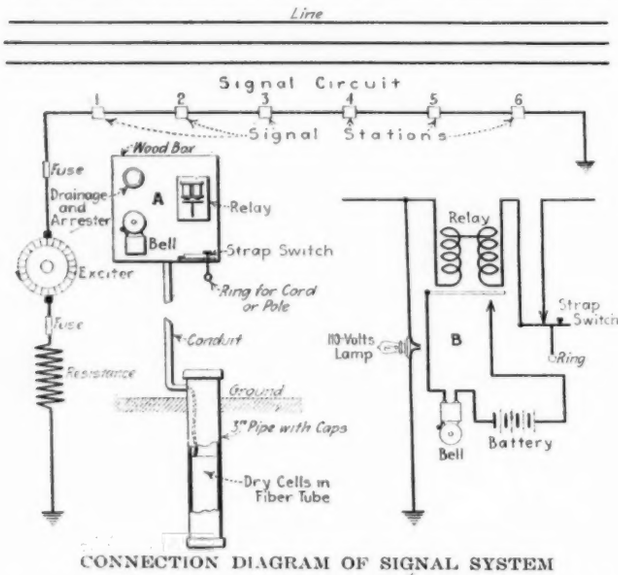
In our plant we have arranged to keep a pair of glass goggles at the chemical tank so that when the chemicals are being handled the operator can put them on. It is worth while to provide this safeguard in every plant handling material of this kind. M. A. SALLER.

Philadelphia, Penn.

Signal System for Use in Place of Telephone

Owing to the difficulties attending the construction and maintenance of a private telephone line paralleling a transmission line on the same poles as the latter, the writer designed a signaling system which has accomplished everything desired.

A single iron wire is run on double-petticoat deep-groove glass insulators and brackets five feet below the crossarm that carries the power wires. The end of this iron wire is grounded at the end of the transmission line



CONNECTION DIAGRAM OF SIGNAL SYSTEM

and is fed from the exciter bus at the power house, the opposite bus being ground through a fuse and fifty-ohm resistance tube, as shown in the figure.

At each substation and at each sectionalizing switch, a twenty-ohm telegraph relay is connected in series with this signal wire, the contact points being reversed so that the relay makes contact when there is no current flowing through it. An ordinary vibrating bell and three dry batteries on the "local" side of the relay complete the arrangement, and a strap switch, normally closed, is inserted in the signal wire at each relay. The general arrangement of a signal box is shown at *A* and the box circuits at *B* in the figure.

As a drainage for static a 50-watt 110-volt lamp is connected from line to ground at each signaling point. Instead of an ordinary lamp socket, a mogul series-lighting socket is used, having a film cutout device, but the film cutout is in this case replaced by perforated sheet mica 0.02 in. thick, to serve as a lightning arrester. The lamp is held in the mogul socket by a reducer. A system of signals and calls has been adopted, which anyone can easily read. For example, the signal 3-1-4 means "Open disconnecting switches (at station called)"; the signal 6-4-1-pause-1-4-7 means "Tree ground, pole 147," etc. In case there is a contingency that cannot be adequately covered by the signal system, the signal 5-1-2, "Get calling station on nearest telephone," is used.

The system described is considerably cheaper than the simplest telephone system, even when signaling stations are spaced at frequent intervals. Since operators handle no live parts, the device is perfectly safe to handle, even during a storm or line trouble. As some of the signaling stations are outdoors, the company has constructed a standard outdoor signaling station which is used at all points, the battery being underground to prevent freezing. R. S. SEESE.

Carthage, Tenn.

Remedy for Present Valve Setting

Regarding the diagrams submitted by S. L. Gilliam on page 518 of the Sept. 23 issue of *Power*, I would say that the head-end steam valve is opening too early. The card shows that admission takes place two or three inches before the piston reaches the end of the stroke, which would cause a severe pound and would also increase the amount of steam used.

The following instructions will answer Mr. Gilliam's request for advice on double-eccentric Corliss engines: Set the steam wristplate and intermediate rocker in central position, and see that with a revolution of the eccentric they travel equally each side of the central positions. Proceed in a similar manner with the exhaust wristplate and the exhaust intermediate rocker. With the steam and exhaust wristplates in central positions, set the steam valve $\frac{5}{16}$ in. *open* and the exhaust valves $\frac{1}{4}$ in. *closed*. Unhook the reach rod, move the steam wristplate by hand and adjust the dashpot rods so that at each extreme position of the steam wristplate there will be $\frac{3}{32}$ in. clearance between the latch and tow plate. Put the engine on the crank-end center, hook up the reach rod and turn the steam eccentric on the shaft, in the direction of rotation of the engine, until as the crank-end steam-valve opening is increasing, it becomes $\frac{1}{16}$ in. Tighten the setscrews firmly in the eccentric and place the engine on the head-end center. With this position of the engine the head-end steam valve should be open the same amount, $\frac{1}{16}$ in., but if it is not, adjust the steam-valve rod so as to make it so, and at the same time adjust the dashpot rod an equal amount. Mark on the engine guides the extreme position of the crosshead. Set the crosshead 92 per cent. from the head end of the stroke, move the exhaust eccentric on the shaft in the direction of rotation of the engine until the crank-end exhaust valve is just closing. Tighten the setscrews in the eccentric *firmly*, and turn the engine over until the head-end exhaust valve is just closing. Measure the distance the crosshead is from the crank end of the stroke, and if the distance varies much from 92 per cent., adjust the valve rod to correct it. Put the governor on the stop, unhook the reach rod, move wristplate by hand and adjust the governor rods so that each latch plate will unhook when the wristplate is $\frac{3}{32}$ in. from the corresponding end of its travel. Raise and block up the governor to such a point that when the wristplate is moved its full travel by hand, each valve-gear latch will unhook just before the corresponding steam valve opens to steam. Fasten the governor collar in this position. Throw out the governor stop and let the governor down to the bottom, move the wristplate by hand and adjust the safety cams on the valve gear so that the latch plates will not hook up. Apply the indicator and correct for any slight defects.

Avoca, Penn. CHARLES J. HALLORAN.

Ideal Methods of Boiler-Room Operation

Volumes have been written on the subject of boiler-room economy, yet lack of system and the reign of chaos may be witnessed in many large and modern power plants. Although a few are giving details close attention, no uniform method of routine operation has been adopted, and one way of doing things is in vogue in one plant and an altogether different method in others.

Most up-to-date engineers agree that coal scales, draft gages, flue-gas pyrometers, CO_2 analysis, steam-flow meters, stoker-speed indicators or counters, automatic-draft control and daily sampling of coal and ash as well as correct tabulations of daily results are not frills and fads, but everyday necessities if ultimate economy is to be secured.

The instruments should be located at convenient and suitable points in the boiler rooms, on boards similar to switchboards, preferably at one central point under the control of an engineer who may be designated as the boiler-control engineer or dispatcher.

The dispatcher should also be in touch with the switchboard operators as to probable changes in the load, so as to prevent the loss of steam pressure or the blowing of safety valves. The chief error in the past, as I see it, is that instruments have been for the use of the testing departments and not for the men that are depended upon to actually operate and get results every day. Too many mere college boys have been playing around, testing a little while at this, then a little while at that, all of which is disconnected and without results. What is most needed, in my opinion, is not testing departments, but results departments, which are allied with the operating and maintenance departments and not separated as by a stone wall. Coöperation is the prime essential all the way through and I am convinced that there is but one way to get it, and that is, to call all of the various executives together first to formulate a plan of operation, then call in the actual operatives and explain to them what you are trying to do and assure them that a certain bonus will be paid to all employees if the results toe up to a certain mark.

Experience has proved to me that an individual bonus for high CO_2 or evaporation is not successful in securing the desired results or economy. The bonus should be paid to all the men concerned, thus eliminating the tendency to practice stunts and to withhold good ideas that would be of value to all. The individual bonus system also produces ill feelings among the men and leads to disorganization.

Other bad results of the individual bonus system are dishonesty, plotting and increased repair bills. The pool system covers the ground more thoroughly, is more flexible, and requires much less accounting, etc.

The motto of efficiency devices should be about as follows: "That which produces coöperation and results is fostered; and that which produces disorganization is tabooed."

The prime essential in producing coöperation, or the family spirit, is to get the men together occasionally for the purpose of discussing subjects pertaining to the work in the boiler room. There are other means of causing men to be interested and satisfied and loyal to the company besides the pay envelope. Some of them are as follows: Make them feel that they are more than mere hands and that they are responsible; teach them from the start that discipline is not humiliation or hardship, but necessary to prevent overwork; spring a variety of surprises in the way of entertainments allied with various forms of educational programs, as a reward for results.

Franklin, Ohio. WALDO WEAVER.

Synchronous-Motor Trouble

A certain synchronous motor began giving trouble at starting about a year ago, and continued to do so until recently, when the trouble was located and remedied. The motor is rated at 135 hp., 220 volts, 900 r.p.m., three-phase, 60 cycles. The stator winding is star connected and contains 24 coils, one coil per slot per pole, commonly known as chain winding.

The revolving field poles are laminated, and each pole is surrounded by a bronze collar that supports the field coils and retains the laminations. The poles do not contain an amortisseur or squirrel-cage winding such as is found on motors of present-day design. This motor is direct-coupled to a 100-kw. direct-current generator and an exciter.

Starting is accomplished by connecting the motor to low-voltage taps on a two-coil compensator. The motor started and ran satisfactorily for years, when all at once it became sluggish and refused to accelerate to a speed anywhere near synchronism when on the starting side of the compensator; nor would it come up to speed when supplied with full voltage. The starting voltage was found to be 1500 volts and all phases practically balanced. However, after several attempts at starting the motor finally came to speed. Intermittently it behaved this way for several months, and was subject to severe treatment that burned out one of the starter coils, and later the stator winding.

After these parts were renewed, the motor failed to accelerate beyond 300 to 400 r.p.m. It was tried with the field winding open and then short-circuited, but all attempts to bring it to speed were futile. As it was necessary to operate the set, provision was made to start from the direct-current end, using a water rheostat to limit the current. In this way it was accelerated to a speed of 500 to 600 r.p.m., when the direct-current was disconnected and the motor connected on the starter and brought into synchronism in the usual way. When on the line it carried a 100 per cent. momentary overload. The exciter voltage, field and line current were the same as before, when rheostats were placed on their old marks.

The problem was discussed with persons of broad experience. A motor having one slot per pole per phase has poor starting ability. Laminated poles are inferior to solid poles as regards starting. It should have an amortisseur winding. But, it started for years, why not now? All agreed that the motor had altered starting characteristics and were interested in how I should eventually come out. It was finally decided to install new field coils. These solved the problem. The insulation on the old coils was punctured between turns and between layers. The high induced voltage in the fields at starting had deteriorated the insulation and burned some of the wires nearly in two. Externally, the coils were apparently in good condition. I read a great deal on synchronous-motor troubles, but nothing that I could find dealt with a similar problem and pointed to field coils exclusively as the cause of trouble.

Rock Spring, Wyo. D. C. MCKEEHAN.

INQUIRIES

Springing a 15-Ton Crankshaft Into Alignment

The main bearings in a large three-cylinder oil engine gave the operator considerable trouble. The bearing shells, which were of the cylindrical steel, babbitt-lined type, could not be kept locked rigid in the frame, and two of them always operated at a dangerously high temperature. I was called in to make an inspection. The operating force was attempting to roll the bottom shell out of No. 3 bearing, Fig. 1, when I arrived. The shaft weighs about 15 tons, and I decided to set a jack under the nearest crank cheek.

Great was our surprise when, after turning the shaft 180 deg. for the purpose of placing the jack, we discovered that the bearing shell, which had just been tight, was relieved and was easily rolled out by hand. Apparently, the bottom shell carried a heavy weight when No. 3 crank was in the inner dead-center and was relieved when this crank was placed on the outer dead-center. It was quite safe to assume that the crankshaft was sprung.

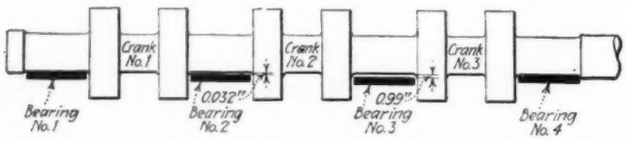


FIG. 1. SHOWING BEARING POINTS OF CRANKSHAFT

My next step was to secure a surface indicator with a range of 0.250 of an inch. The bearing shells were then removed from Nos. 2 and 3 main bearings so that the shaft rested in the two end bearings Nos. 1 and 4. The surface indicator was placed on top of No. 3 main-bearing journal and the shaft revolved one complete revolution. The readings showed an eccentricity in this journal of 0.162 in. In the same manner No. 2 journal was found to run 0.065 in. out of true. The maximum eccentricities of both journals were found to be in the same plane and in the highest vertical position when No. 3 crank was on the outer dead-center.

It seemed necessary to dismantle the engine, which involved taking off the rotor, and to ship the shaft to the factory to be trued up and have all main bearings rebabbitted to fit the size of the journals after they were turned down. However, the engine furnished power for a large industrial mill, and a long shutdown necessary to do this work would result in large losses to the firm and its employees. All the repair work so far had been done on Saturday afternoon and Sunday, and it caused no delays.

The crankshaft, as shown, is built up and there are no keys or pins in the shrunk joints. I decided, therefore, to put No. 3 crankpin under torsion and slide it 0.031 in. in the joint where it is shrunk into the cheek. This joint was 13 in. in diameter. The distance from the center of the crankpin to the center of the crankshaft was 17.25 in., therefore it would be seen that about 0.031 in. in the crankpin joint circumference would move the main journal 0.081 and would cause it to run true, as its total eccentricity was 0.162 in. It is true that by slipping No. 3 crankpin joint 0.031 in., not only No. 3 journal but Nos. 2 and 1 as well, would be shifted 0.081 in. off center relative to the remaining part, or the other end of the shaft, while the surface indicator showed only 0.065 eccentricity in No. 2 journal and No. 1 journal was turning true. However, it was reasoned that had it been practicable to support the shaft in No. 4 journal and the outbored bearing only with the shells removed from No. 1 journal also, the surface indicator would have shown 0.162 in. eccentricity in Nos. 1 and 2 journals as well. The weight of the crankshaft caused it to rest always

MICROMETER READINGS

At Start	Under Strain	Strain Off
302	455	396
396	465	405
405	492	432
432	500	448
448	507	450
450	510	451
451	520	460
Checked No. 4 journal showed 0.020 in. eccentricity.		
449	484	450
450	523	462
462	530	480
Checked No. 4 journal, 0.006 in. eccentricity.		
479	514	479
479	535	479
479	545	485
Checked No. 4 journal, 0.003 in. eccentricity.		

in No. 1 bearing and therefore run true at this point and at the same time decrease the eccentricity in No. 2 journal.

A large steel Z-shaped hook was made up and used in connecting with a 100-ton hydraulic jack as shown in Fig. 2. This rigging enabled us to apply about 1,020,000 lb. torsion in the 13-in diameter shrink joint which it required to start it. The pressure gage on the hydraulic jack made it easy to compute the pressures.

In order to be able to measure accurately the amount which the joint slipped, an inside micrometer was used between two points located 32.5 in. from the center of the crankpin. At this point 0.005 in. would correspond to 0.001 in. movement in the circumference of the 13-in. diameter shrink joint.

The table shows how the joint was moved gradually a few thousandths at a time. The strain on the jack

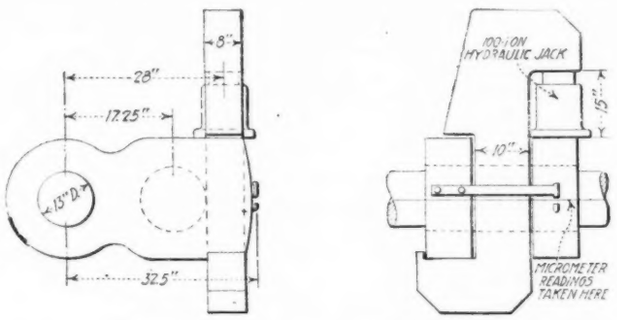


FIG. 2. APPLICATION OF JACK FOR SHAFT ALIGNMENT

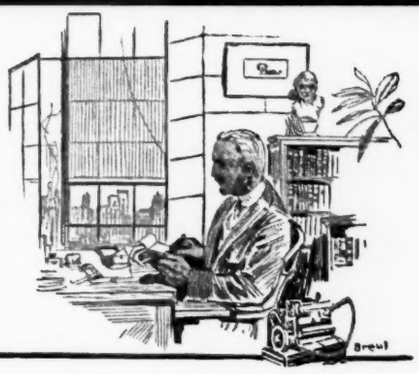
of course had to be relieved every time the position was checked. It will be noticed that actually the joint was slipped about 0.039 in. before the journal checked true. This was due to the fact that the weight of the crankshaft decreased the eccentricity by causing it to run true in No. 1 journal.

When the bearings were again assembled they were given 0.006 in. clearance, and when the engine was started the shaft ran true and bearings remained cool.

Newark, N. J. RALPH MILLER.

It has always been considered dangerous to those handling a hose line to allow the stream to come in contact with an electric circuit. Prof. F. C. Caldwell has found by experiment that there is no danger of shocks when the distance between the nozzle and circuit is more than 25 ft. irrespective of the voltage.

INQUIRIES OF GENERAL INTEREST



Holding Power of Flared vs. Beaded Tube Ends—What is the relative holding power of boiler tubes having the ends simply flared by the expanding tool, and when beaded over? F. C.

Beading over the tube ends, unless done with great care, has a tendency to weaken the hold of the tube and also to injure the texture of the material. With ordinary workmanship, the holding power is about 10 per cent. less than when the tube end is simply flared, but when beading is carefully performed upon metal of good ductility, the holding powers of beaded and flared tubes are sensibly equal. The durability of beaded tubes in resisting the action of fire is so much greater than when the tubes are simply flared that beaded ends are to be preferred.

Reason for Greater Lap on Head End of Valve—Why should there be more lap of a D-slide valve for the head end than for the crank end of an engine cylinder? W. R.

On account of the angularity of the connecting-rod there is less number of degrees rotation of the crankshaft and eccentric during the half-stroke in the head end than in the crank end of the cylinder. Therefore with equal laps, cutoff would occur later in the stroke from the head end and, to more nearly equalize cutoff, more lap must be given to the valve on the head end. But with a direct-acting eccentric rod, or valve gear provided with a straight rocker, it is not practicable to add sufficient lap to entirely equalize the points of cutoff, because the addition of lap on the head end reduces the lead on that end and lead is of more importance than equalization of cutoff. The unequal lap should not be more than will result in the greatest lead permissible for the crank end and the least necessary for the head end. Equalization of both lead and cutoff can be obtained by employment of a properly designed bent rocker.

Trouble from Long Pump Suction Pipe—Trouble is experienced in operating a 6 x 7 x 12-in. light service pump on account of leakage in the 4-in. suction pipe, which is 1300 ft. long. The suction pipe is buried 4 ft. below the surface of the ground. What would be the best way to locate the leak? F. B. S.

A tight suction pipe, of the length stated, is likely to become airbound in a short time from liberation of air out of the water during the great length of time the water is traversing the pipe while under less than atmospheric pressure and that trouble is commonly mistaken for a leak or solid stoppage of a long suction pipe. Before assuming that a leak has developed, it would be well to stop the entrance end of the pipe and use water from a tank under pressure or employ the pump for testing whether the pipe is tight against pressure. If it is found to be pressure-tight, the air "plugs," which usually consist of accumulations of air bubbles, will have to be pushed out of the pipe by forcing water through it. If the pipe is found to have a leak, its location can be determined by making pressure tests of different sections, beginning, for instance, at the middle of its length and testing each half, thus narrowing down the search to a small section of length that contains the leak. In most soils where the leak is considerable, its location will become revealed on the surface of the ground by keeping the pipe under water pressure for 12 to 24 hours.

Salvage of Blowoff Water—We have sixty-six 84-in. x 20-ft. horizontal return-tubular boilers and cut out three boilers daily for cleaning, discharging the boiler water to the public sewer. In addition to this waste of water, the boilers in use are blown down about three inches three times daily. Could not this water be discharged to a settling tank and be used over again as feed water instead of replacing it with fresh water from the city supply, which costs about one cent per 50 gal.? J. C. M.

Blowoff water usually contains a concentration of objectionable impurities and, without purification, would not be desirable for use, excepting in an emergency or where there is great scarcity of water. The waste of water described amounts to about 45,000 gal. per day, and at the excessive charge of one cent per 50 gal., or $200 per million, the expense of replacing the blowoff water is $9 per day, or only about 14 cents per boiler, an amount that does not appear to warrant salvage and purification of the blowoff water to render it suitable for boiler feed.

Testing Parallelism of Engine Guides—How can a test be made to determine whether the guides of a horizontal engine are parallel with the center of bore of the cylinder without removing the piston, piston rod or crosshead? D. A. S.

The center line of an engine cylinder usually is considered to be the line passing through the centers of the counterbores. However, if it is desired to make comparison of the guides with the center of the bore, it would be well to assume the center line of the bore to be a line through the centers of the bore at each end of the stroke of the piston. To establish such a center line without stripping the engine of the piston, piston rod or crosshead, remove the cylinder head and place the crank on dead-center away from the cylinder, to bring the piston at the crank end of the stroke. Wedge a wooden rod across the cylinder bore near the piston for holding one end of a light but strong line at the center of the bore, and secure the other end of the line to a stationary object at a distance of about six diameters of the bore beyond the head end. Draw the line as tight as possible and adjust the ends of the line so it will be central with the bore vertically and horizontally at both ends of the stroke of the piston. Then tightly stretch a second line of the same kind from the top of the cylinder, vertically over the first line and parallel to it, by careful measurements and plumbing from one line to the other. Stretch a third line parallel to the first and second lines, over or to one side of the cylinder the full length of the first lines, and beyond the guides, for a reference line. Carefully test the parallelism of the reference line with both the first and second lines, using a distance piece made of a light wooden rod with ordinary pins in each end. If in any case careful sighting along a line reveals sag, stretch another line a short distance above the sagging line by careful plumbing and, by replumbing, locate a supporting point for the line at about the middle of its span. Fasten to the crosshead a pointer terminating in a V opening that all but touches the reference line and after rechecking all adjustments remove the line and blocked rod from the cylinder. Then to test parallelism of the guides slowly turn the engine over, preferably backward, and observe whether the crosshead carries the pointer uniformly at the same distance from the reference line for the full length of a stroke.

Mexico, a Petroleum Storehouse*

MEXICO is the veritable land of promise and broken promises, of great natural wealth and abject poverty. From the days of Cortez the allurement of its natural resources has made an irresistible appeal to foreign capital and enterprise. Unfortunately, it is characteristic of a Mexican impulsively to stake all he owns on a cock fight, but to be unwilling to risk his savings in testing the mineral possibilities of his own farm. Consequently, nearly all the large public utilities, as well as the industrial developments of the country, have been promoted by foreigners.

The oil and asphalt seepages of the "Huasteca Region" in the states of Vera Cruz and Tamaulipas are frequently mentioned in the writing of the early Spanish explorers. The first attempt to drill for oil was made at Furbero by an Englishman named Autrey in 1869, but no important discovery was made until 1904, when a group of California capitalists brought in the first gusher at Cerrito de la Pez, near Ebano. From then on, however, oil field development has been rapid. About four years later the Pennsylvania Oil Co. drilled the famous Dos Bocas well, which burned for 57 days and could be seen at night by ships 30 miles out.

Big strides were made in 1910. Among the principal events of that year were the discovery of the Panuco field and the completion of the Juan Casiano and Potrero del Llano wells. It is safe to say that these two wells combined have already produced nearly 200,000,000 bbl. of oil, which is a record that has never been surpassed anywhere in the world.

In 1911 the first shipments of Mexican crude were made from Tampico to the United States, and the production jumped that year from four million to more than thirteen million barrels. At present Mexico is making an annual production of 75,000,000 bbl. from not more than 200 wells, or about one-fifth as much oil as is produced in this country from over 225,000 wells.

Today there are nearly 500 companies operating in the oil fields of Mexico, but less than a score of them can be rated as important producers. The ones which have now attained a solid footing expended unlimited sums of money for development when their future looked precarious. They have overcome innumerable difficulties and maintained an optimistic outlook all through the revolutionary disturbances.

Realizing years ago that Mexico promised to become the world's greatest producer of low-grade oil, the Standard Oil Company (N. J.) long since prepared to meet the new conditions as they materialized. At present the company is not by any means the largest producer in Mexico, but it is well established with a growing organization under the name of the Compania Transcontinental de Petroleo, S. A. The Standard Oil Company (N. J.) put into service the first large fleet of tank steamers to carry Mexican crude. At Tampico, now one of the important oil depots of the world, the Mexican company has an immense tank farm and a topping plant. It has tugboats on the river and is building a terminal loading station on the Gulf Coast, where the oil is piped out to sea and loaded in ships standing a mile or more off shore.

Potentialities of Mexico

The importance of Mexico in the oil business of the world today is but little appreciated. About 25 per cent. of its potential production is now being shipped.

Publications have estimated the possible daily production of the Mexican fields for the last few years as follows:

	Barrels		Barrels
1915	600,000	1917	850,000
1916	725,000	1918 and at present	1,000,000

At the same time the average daily shipments from Mexico during this period are shown below:

	Barrels		Barrels
1915	66,798	1917	126,175
1916	82,209	1918	152,363
First eight months, 1919			207,800

The extraordinary record of Mexican fields is more surprising when we appreciate that the real development is only fifteen years old. The producing business in Mexico can be said to have started on a practical basis in 1904 with the drilling operations of Messrs. Doheny, Canfield and others at Ebano. These operations were prompted by a desire to find oil for supplying railroads in the United States with fuel. The second important step in the development of the producing business was the opening of the so-called Southern field in 1910, when the Doheny interests drilled in the famous Juan Casiano well and the Pearson interests drilled in the equally famous Portrero del Llano. The latter was destined to produce 100,000,000 bbl. before it was drowned out by salt water in the past year, and the former, with a record of more than 80,000,000 bbl., is still producing 23,000 bbl. a day through a damaged gate valve which has not been moved for years.

The Mexican oil fields are divided into three distinct fields as regards location as well as quality of crude produced.

The Isthmus of Tehuantepec has not been a profitable field. The oil found is of good quality, about 36 Bé. In this field there have been a total of 221 wells drilled, which today have a total production of about 500 bbl. from 75 producing wells, all others having been abandoned. The Pearson interests initiated their efforts in the Mexican field in this region, and built a refinery at Minatitlan, which now depends principally on the other Mexican fields for crude, which it receives by tank steamer.

Another oil-producing region is generally known as the Northern field and produces a heavy crude varying from 8 to 15 gravity Bé. This field lies from twenty to fifty miles in a westerly direction from Tampico. It includes the fields of Ebano, Panuco and Topila. Panuco furnishes about 85 per cent. of the production of the field, and its crude has a gravity of 12 Bé. In the Northern field approximately 250 wells have been drilled, of which 150 are at Panuco.

The most important Mexican field is the Southern, or so-called "light oil" district, which starts at Tepetate, about 70 miles south of Tampico, and extends in a southerly direction to the Tuxpam River, a distance of about 35 miles. In this field the oil is about 21 gravity Bé. and the potential production is over 500,000 bbl. a day. This production is the result of drilling 185 wells, of which 68 are productive.

In the Southern field, the oil is transported by pipe line, but it is the usual practice to maintain a railroad from tidewater to the field. The railroads are about twenty miles long, fully equipped for handling freight direct from the wharves to the fields.

An extraordinary characteristic of the wells in both the Northern and Southern fields is the steadiness of the flow. The production is obtained, more especially in the Southern field, in the very porous limestone known as the Tamasopa. Where this formation outcrops, some 60 miles farther west, enormous caverns are found. The samples of the rock which are flowed from the wells when drilling them in look almost like honeycomb. The thickness of the formation is generally spoken of as from one to three miles, which is, in a measure, an explanation of the unusual staying qualities of the wells.

The wells, when shut in, show a pressure of from 300 to 1000 lb., depending on the locality. When the wells are being flowed, the gate valves on the big ones are generally opened from one to three turns, where full opening of the 8-in. valve used is about 27 turns. While the wells are being flowed under such conditions, they hold back pressure of from 200 to 700 lb. The oil as it comes from the well is 120 to 150 deg. F.

The water that flows from these wells following inundation is of even higher temperature, this situation being peculiar to limestone formations. The hot oil is much easier for the pumps to handle, an advantage which is fully appreciated.

The most extraordinary natural seepages of oil in the world are found in Mexico. Long before oil was produced from drilled wells, these seepages supplied asphalt, and the streets of Vera Cruz are paved with asphalt from seepages near the Tuxpam River. These seepages made a death trap for cattle and wild animals in the vicinity, and the numerous skeletons of all kinds bedded in the soft asphalt are mute witnesses of the effectiveness of these pitfalls afforded by a freak of nature.

*From *The Lamp*, published by the Standard Oil Co. of New Jersey for its employees.

In the Northern field the heavy oil from the Panuco and Topila districts is generally brought to Tampico with barges and stern-wheel steamers similar to those seen on the Mississippi and Ohio rivers. This is due in part to the opportunity afforded by the Panuco River, which at all seasons permits barges of seven-foot draft to operate 65 miles by water from Panuco. These barges hold from 6000 to 8000 bbl. each and are approximately 40 ft. wide and 200 ft. long. A large steamer generally has seven barges as her complement. She takes three empty barges from Tampico to Panuco, waits two or three hours for them to be filled, and returns to Tampico, making a round trip in 24 hours. These barges are left at the deep-water terminals to be pumped out into tanks ready for delivery to the tank steamers. The steamer leaves the three full barges, takes three empty barges and proceeds on another voyage. While she is away, the barges are pumped out in the course of six or eight hours, ready for the steamer on her return trip. One barge is generally under repairs, principally due to work of the teredo, which attacks any timber in the water, eating holes through it until it looks like honeycomb. An unusual characteristic of this pest is that it will not go from one plank to another, crossing a seam. The defective planks are removed from the bottom of the barge, frequently their weight being only 15 or 20 per cent. of what it was when new, the rest having been consumed by the teredo.

The loading of steamers in the Southern field is interesting and a departure from the usual practice. The steamers are loaded on the Gulf Coast by pipe lines which are run from one to two miles out from the coast to the steamer's moorings and the oil is delivered to the vessel while she is at sea.

The so-called sea lines are first laid ashore. The entire length of the line is then put on small cars on a railroad and pulled out to sea by tugs. When it is appreciated that these are 8-in. or 10-in. lines more than a mile long it is surprising to see the ease with which they are hauled out, provided no accident happens during the critical half-hour that the line is moving. If a considerable part of the line is in the water and an accident causes it to stop moving, it is frequently impossible to continue hauling it out, as it sticks in the sand and has to be recovered in sections by the aid of divers.

These lines are hauled out to about 40 ft. of water. On the end is an 8-in. hose about 100 ft. long attached to a small wooden buoy. Around the end of the pipe line, about 400 yd. apart, are placed four or five buoys to which the tank steamer secures before connecting up her hose to receive oil. After being moored she connects up the two hose, as it is the practice to lay two sea lines to each steamer berth, and signals to the pump station ashore to start pumping oil. This oil is then delivered at a rate of from 4000 to 6000 bbl. an hour. As the coast is little protected, the surf always makes communicating with the ship a difficult problem, and the men who handle the surf boats have many lively experiences, particularly in the winter when bad weather is the rule, rather than the exception.

When a Mexican Gusher Comes in

Ordinarily, the hole is drilled to within 300 or 400 ft. of the pay with a rotary. Pipe is then cemented, tested to 750 to 1000 lb. pressure, and gate valves are put on, which can be closed any time the well comes in. When it is expected that the pay may be reached, steam is kept up in a reserve boiler at a safe distance from the well and a man is stationed at the drilling boilers to turn out the fire at the first alarm. A man is stationed to close the gate valves and another one ready to pull out the tools.

The first indication is that water used in drilling starts to flow and generally within ten minutes the whole story is told if no accident occurs. The well throws the water and drilling tools out of the hole over the derrick. The man at the boiler shuts out the fire and turns steam into the firebox to prevent a conflagration. The man at the gate valves stands ready to close them the instant the tools have been blown out. The derrick is reinforced with heavy timber and tank steel so that the tools cannot fall back on the valves and break them off.

Frequently, in spite of all precautions, the wire drilling cable fouls the tools so that they stick in the pipe, resulting in a fishing job, while the well is flowing several thousand barrels. While the cable is still in the hole, of course, the gates cannot be closed. Where the preparations have not been sufficient or an accident occurs, it is frequently followed by disaster to the well as well as to the men.

A world-famous example is the Dos Bocas well, about ten miles north of Tepetate, which came in without being controlled, flowed thousands of barrels a day, caught fire and burned for some sixty days until it extinguished itself, the flow of oil having been replaced by a geyser of hot salt water. This is now a sort of salt-water volcano, the crater being half a mile in diameter and producing about 1,000,000 bbl. of boiled salt water a day.

In the famous Potrero del Llano well an accident to the casing made it impossible to shut the well in and resulted in seepages coming up through the ground for a radius of half a mile. While the well was producing 46,000 bbl. a day for years, half of the production came through the casing and the balance from these seepages, due to the enormous pressure on the well and the leaking through the defective casing.

The country is largely covered with jungle full of all manner of game, although the jungle is so dense that animals can only be seen in the narrow trails or along the rights-of-way which have been cleared by the operators for their pipe lines and railroads. The waters abound with fish, so that only the choicest varieties are even worth offering for sale.

The climate, although just within the tropics, is not as intensely hot as would be imagined, thanks to the trade wind which blows during the hot months from 10 o'clock in the morning until after midnight. From June until September is the rainy season, during which time there is a very heavy rainfall and passage through the country is extremely difficult on account of the mud. It is this difficulty which has compelled the operators to build railroads rather than roads for transportation between the waterways and the fields.

The drillers live in camps with Chinese servants. It would almost seem that without these Chinamen work in the remote districts would be next to impossible. The commissary supplies come largely from the United States, although fruit and vegetables are abundant in Tampico. The soil is extremely fertile, and vegetables of almost any description can be planted any day in the year.

Any article touching on the producing business in Mexico, however general, would be incomplete and unjust without paying tribute to those men who live in the jungle, exposed to the greatest hardship and dangers, removed from all bases of supplies, who by their perseverance, ingenuity and courage bring in and master such enormous wells, accompanied with a flow of deadly sulphur gas. Particularly was this true during the war, when the conditions were the worst from all standpoints, and the importance of the Mexican production, which is essentially fuel oil, for the use of the Allies, was of vital importance.

RUB-A-DUB, TWO MEN IN A TUB

Steamboat Inspection Service Amends Its Rules

Section 4433 of the revised statutes, as it at present reads, is unsuited to modern practice, and the Bureau recommends that it be amended to read as follows: "The working steam pressure allowable on all boilers inspected as required by the L. II. shall be determined by the rules of the Board of Supervising Inspectors with the approval of the Secretary of Commerce." The purpose of the proposed amendments in this section are, first, to do away with the obsolete rules contained in the present law which prescribes a working steam pressure for single-riveted joints without taking into consideration the percentage strength of the riveted joint, and allows 20 per cent. additional pressure for double-riveted joints, but which does not allow a greater working pressure for triple- and quadruple-riveted, etc., lap and butt joints, for which greater working pressure should be allowed on account of the greater strength of the triple-riveted and other joints of greater strength than the double-riveted joints. There is a provision of the section which reads: "No split-calking shall in any case be permitted." This has been omitted in the amendment, as the rules for calking would be prescribed by the Board of Supervising Inspectors in connection with the rules for riveted joints.

Section 4418 of the revised statutes with reference to hydrostatic pressure tests of boilers reads as follows: "All boilers used on steam vessels as constructed of iron or steel plates inspected under the provisions of the section 4430 shall be subjected to a hydrostatic test in the ratio of 150 lb. per sq.in. to 100 lb. per sq.in. of working steam pressure allowed." In the recommended amendment this part of the section is made to read: "All boilers used on steam vessels and inspected as required by L. II. shall be subjected to hydrostatic tests as shall be determined by the rules of the Board of Supervising Inspectors with the approval of the Secretary of Commerce." It is the desire of the Bureau that the amendments be enacted into law, so as to leave with the Board of Supervising Inspectors the authority for determining the hydrostatic test in connection with the rules for riveting which would be adopted by the Board, all of such procedure, of course, to be approved by the Secretary of Commerce.

The purpose of these and other amendments is to bring the Supervising Inspector's rules up to date and facilitate the rehabilitation of the American Merchant Marine.

New York Engineers Loyal

The largest meeting of engineers or firemen ever held in this country took place at Cooper Union, New York City, Dec. 11, 1919. The meeting was arranged by Locals Nos. 20, 56, 96, 319, 379, 608, 615 and 670, International Unilon of Steam and Operating Engineers, and Local No. 56, International Brotherhood of Stationary Firemen.

The purpose of the meeting, as expressed in the invitation extended to all engineers and firemen of New York, by the arrangement committee, was "the formulation of a wage scale for engineers, firemen, oilers, etc., in all steam plants of Greater New York and for the betterment of the crafts in general." The committee invited the general officers of both organizations and representatives of the American Federation of Labor.

At 8 p.m., when the general and local officers, members of the arrangements and invited guests appeared on the platform, the great hall, having a seating capacity of 2500 or more, was packed.

Joseph Monterfering, of Brooklyn, called the meeting to order and stated the first business was the selection of a chairman. Matt. Comerford, past general president of the I. U. S. & O. E., now with POWER, was selected as permanent chairman. P. J. Horan, of Local No. 20, I. U. S. & O. E., and Mr. Flannagan, of Local No. 56, I. B. S. F., were selected secretaries. After briefly reciting the history of the organizations and the principles on which they are based, the chairman introduced the following speakers:

James P. Holland, president New York State Federation of Labor; W. J. Collins, organizer, American Federation of Labor; Milton Snellings, general president, I. U. S. & O. E., Washington, D. C.; Timothy Healy, general president, International Brotherhood of Stationary Firemen, New York; Arthur M. Huddell, first vice president, I. U. S. & O. E., Boston, Mass.; H. M. Comerford, general secretary-treasurer, I. U. S. & O. E., Boston, Mass.; Edw. F. Moore, examiner of engineers and president of Local Union No. 569, of Chicago, Ill., and Joseph Monterfering, third vice president, I. U. S. & O. E., Brooklyn, N. Y.

The following resolutions were submitted to the meeting and unanimously adopted:

RESOLUTIONS

Whereas, There are today in the Greater City of New York about forty thousand steam-plant employees, comprising engineers, firemen, oilers, etc., employed in factories, public institutions, office buildings, loft buildings, hotels, apartment houses and various other plants; and

Whereas, These men, who must be American citizens, and pass examinations as to their fitness in order to receive licenses, all hold very responsible positions, being intrusted with the care and operation of plants that are essential to the preservation of the lives and property as well as the safety and comfort of millions of people every day; and

Whereas, There prevails today in the trade and calling of steam-plant operatives a scale of wages far below that of the average American mechanic and in some instances below that of the ordinary day laborer, the wages received being out of all proportion to the present high cost of living, while the working hours are much longer than those of the average mechanic; therefore,

Be It Resolved, That this mass meeting of engineers and firemen assembled in Cooper Union, Thursday evening, Dec. 11, 1919, authorize our various local unions in the City of New York to select a committee to be known as a Wage Committee, which shall be vested with full power to present to the Hotel Men's Association, Real Estate Men's Association, Merchants' Association and other groups of employers the demands of the men of our crafts for a uniform scale of wages, reasonable working hours and one day's rest in seven.

That we pledge our undivided support to any committee that may be selected, and promise to use all honorable and legitimate means within our power to induce employers to adjust matters in dispute so that engineers, firemen and other steam-plant operatives may be placed on an equal footing as regards wages and hours with all other mechanics in the City of New York.

Be It Further Resolved, That we reiterate our loyalty and devotion to this American Republic and denounce any attempts to subvert our established forms of government. We hereby pledge ourselves to coöperate with any agency patriotically striving for industrial peace and endeavoring to bring about harmonious relations between employers and employees.

Steam Versus Electric Main-Roll Drives for Steel Mills

On Saturday, Dec. 20, 1919, at the Hotel Chatham, Pittsburgh, Penn., the Association of Iron and Steel Electrical Engineers held its December meeting of the Pittsburgh Section. The meeting was preceded by a dinner and entertainment, which proved to be an enjoyable function. President D. M. Pettie presided at the Technical Session, which was devoted to a discussion of Steam Versus Electric-Driven Mills. The discussion was opened by G. E. Stoltz, who explained by the use of moving pictures the operation of both steam and electrically driven reversing blooming mills. It was the opinion of Mr. Stoltz that steam was used to the least advantage when the mill was driven by steam engines, and that due to many advantages of the electric drive over the steam drive for rolling mills, the last ten years have seen a wide application of electric motors to the driving of these mills.

Mr. Seibert, of the Bethlehem Steel Co., felt that in almost all cases the electric drive could produce steel at a lower cost per ton than could be done with the steam-engine drive, although in some small isolated steel mills it might be found more economical to use steam drive. However, a careful study of all factors should be made in every case before de-

ciding upon the type of drive. The speaker called attention to the lack of reliable data on the power requirements for steam drive, and presented by the use of lantern slides the results of investigations which he has made on steam and electric-driven reversing blooming mills. The results of these investigations showed a power cost per ton of $1.33 for the steam-engine drive against $0.76 for the electric drive. However, no fixed rule can be laid down as to the relative economy of steam and electric drive.

The uniflow engine was discussed as a possible competitor of the electric motor for driving steel mills. The nonreversing engine has been developed to where it can be used and is being used on main-roll drives, but the reversing type has not reached this stage of development.

K. A. Pauly pointed out that the question of steam engine versus electric drive for rolling mills resolved itself into a reversing blooming-mill problem, and if the electric drive could be developed to a point where it could produce the tonnage that is being obtained with steam-engine-driven reversing blooming mills, then there would be little question of the superiority of electric drive over the steam drive. Mr. Pauly no doubt created somewhat of a surprise for many when he said that all high-production reversing mills were steam-driven, and that in no case was there an electric-driven reversing mill that could compete with the steam-driven mill in production. However, the low-cost-production mills are electrically driven, but although cost of production is an important factor, it is frequently outweighed by high production in the minds of steel-mill men, since tonnage is the thing that they are after. The speaker called attention to the steam-driven mill rolling sixty or more ingots per hour, and said that in no case was there an electrically driven mill that was doing this. Mr. Pauly then told of some of the work that was being done at the Trumbull Steel Co.'s plant with an electrically driven reversing mill and said that they eventually expected to have this drive in such shape that it would be capable of a production equal to any steam-driven mill. This is also the case at the Sparrows Point Mill of the Bethlehem Steel Co., where they are rolling as high as 56 ingots per hour.

E. S. Jeffreys, electrical engineer for the Steel Company of Canada, gave the record of a 34-in. electrically driven reversing mill that had rolled 692,012 net tons without one minute's delay on account of the main-roll motor. In this mill the power requirement to drive the roll is about three times that required by the auxiliary drive. The cost of rolling a ton of steel in this mill averages 32.7 cents.

A great amount of detailed data was given in the discussion on production and cost of production with the two types of drives. Unfortunately, this material is not available for publication at this time, but no doubt will be in the near future, and a digest of it will appear in these columns.

A New Type of Hydraulic Turbine Runner*

By Forrest Nagler

The progress in waterwheel development has been more nearly connected with increase in speed than with improvement in efficiency. The development of high-speed electric generating machinery has continually called for increase in speed, especially for low-head sites.

The designers of waterwheels have had to meet a very wide variety of conditions due to nature's inconsiderate failure to standardize waterfalls. In practice waterwheel runners vary in dimensions, horsepower, speed and the head under which they operate.

To compare two wheels operating under different conditions, the first step would be to compute their power and speed when under the same head. This still leaves variations in power, speed and dimensions, so a second step is necessary. This second step may be:

A. Recompute and compare their powers on the basis of being so changed in dimensions as to have the same speed; or,

B. Recompute and compare their speed on the basis of the same power.

*Abstract of a paper presented at the Annual Meeting of the American Society of Mechanical Engineers, New York, Dec. 2-5, 1919.

Basis A would give a *characteristic power* and is the method used by Professor Jowski in the *Engineering Record*, Dec. 26, 1914. Basis B gives a *characteristic speed* and is the more general practice. This characteristic may be defined as follows:

The *characteristic speed* of a runner is the speed in r.p.m. which a model of that runner would have if operated under a head of 1 ft., this model to be reduced proportionally in all dimensions from the original until it will develop 1 hp. under 1-ft. head.

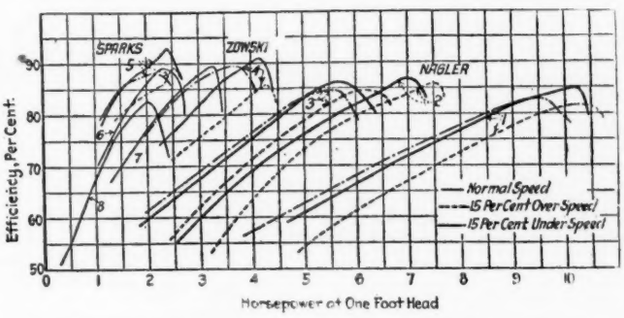
From the hydraulic laws governing the variation of power and speed of runners, it is shown that

$$N_s = N_1 \sqrt{hp.} = \frac{N \sqrt{hp.}}{\sqrt[4]{H^5}}$$

hp = The horsepower of a runner;
N = The revolutions per minute;
H = The head in feet;
hp_1 = The horsepower under 1 ft. head;
N_1 = The r.p.m. under 1-ft. head;
N_s = The characteristic speed.

As an illustration of the universal application of the basis of comparisons, the accompanying table is given, which contains examples from actual installations.

Historically, the progress in hydraulic-turbine building may be illustrated by noting the increases in characteristic speed. The earliest types of waterwheels, antedating the Christian Era, were the current wheels, which developed into overshot, undershot and breast wheels. Their characteristic speed had



POWER-EFFICIENCY CURVES FOR WHEELS HAVING A NORMAL SPEED OF 50 R.P.M.

a maximum of possibly three, and as a consequence of their low heads their r.p.m. averaged probably under 20.

Between 1825 and 1840 Fourneyron developed the radial-outward-flow type and Jonval developed the axial-flow type, but demands for speed and capacity were such as to limit characteristic speeds to between 20 and 40 and capacities to considerably under 1000 hp. About 1870 Francis developed the radial-inward-flow type, which gradually changed until the water entered radially and was discharged axially. This type is especially an American product, and its characteristic speed has gradually increased from about 40 in 1870 to a little over 100 in 1914. The last increases, made by Zowski, were the basis of great advance in the design of low-head units. The new type of runner described by the author will give a characteristic speed of about 160.

In 1907 the author was engaged in field work on large-sized axial-flow pumps. Impressions gained in this work influenced his trend of thought in his later hydraulic-turbine work so that the Francis-type runner seemed unnecessarily complicated. From these ideas a definite application of the axial-flow principle was developed in 1913. The new design is based on a straight radial blade somewhat similar to a marine-propeller blade, which offers a minimum of wetted surface, and of bending moment at the root of the blade. Models were made, tests run, and such refinements added as seemed advisable. Tests on models were verified by tests on real runners at Holyoke in 1917.

Some characteristic curves are shown in the accompanying plot, where characteristic horsepowers are plotted against efficiencies. Curves Nos. 1, 2 and 3 are from the new-type runner, while No. 5 is from the runners of Professor Zowski.

From these curves the following may be deduced: For any given conditions of head and speed the runner No. 1 will give 140 per cent. and No. 2 will give 65 per cent. more power than types previously available as typified by No. 4.

Comparison on a speed basis, using equal power, shows that runner No. 1 will give over 50 per cent. and No. 2, 30 per cent. higher speed than No. 4.

The primary advantages shown by the new type-runner are as follows:

(a) Lower generator cost due to increased speed. This may be from 15 to 35 per cent.

(b) Lower turbine cost due to simpler runner. This averages around 10 per cent.

(c) Smaller generator diameter and therefore smaller power house.

(d) Higher generator efficiency due to better design possible with the higher speed.

(e) Greater turbine flexibility, which permits more power under flood conditions when the head is reduced.

This new type of runner is from the direction of flow a pure Jonval type, although Jonval's wheels seldom had characteristic speeds in excess of 20 or 30 and his blades were different. The primary essential of high characteristic speed is a reduction of hydraulic friction and centrifugal forces. Theoretically, high characteristic speed may be obtained by flattening the blade angles. Practically, this results in increasing the wetted surface and so reducing the efficiency due to friction. In the author's design these effects are counteracted by cutting out blades, which does not result in decrease of power, as might be expected.

In conclusion the development of this runner would offer such possibilities as the use of a 30,000-lb. casting, very simply made and easily transported instead of one weighing 130,000 lb. and ranking among the most complicated castings ever made, which was used at the Keokuk plant. With any given minimum generator speed the new runner will permit operation under heads one-half as high as those required in prior practice and for large powers units may be developed at lower costs.

COMPARISON OF OLD- AND MODERN-TYPE HYDRAULIC TURBINES

	—Old Types—		——————Modern Types——————			
		Fourneyron (Tremont)	Nagler	Usual Mixed-Flow or Francis		Impulse (Pelton)
Item	Overshot Wheel	Turbine	High Speed Low Head	Medium Speed	Low Speed Dbl. Run	Twin
Head in feet, H.	14	14	14	200	400	2,000
Horsepower, total	50	180	500	40,000	20,000	20,000
Runner horsepower, HP....	50	180	500	40,000	10,000	10,000
Speed, r.p.m., N..	10	53	200	150	360	375
Runner diam., in., d.....	144	40	72	130	72	96
Unit horsepower, HP_1.....	0.95	3.44	9.55	14.14	1.25	0.11
Unit speed, r.p.m. N_1	2.67	14.16	53.50	10.61	18.00	8.39
Characteristic speed, r.p.m., Nc	2.66	26.30	165.00	40.00	20.00	2.78

The Steam Turbine*

By E. H. Sniffen

Manager, Power Section, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Penn.

Why was it that the steam turbine, being the earliest form of heat engine, remained in an undeveloped stage, while for a period of more than a hundred years the reciprocating engine became the only type of prime mover? The answer is that the development of the steam turbine as we know it today was delayed until the mechanical arts and the knowledge of materials had progressed sufficiently to make its construction possible. Comparatively speaking, the reciprocating engine was an easy thing to build. The steam turbine is in reality a metallurgical achievement. It could not well have come earlier.

We find in the British patent records many steam-turbine inventions occurring between the years 1800 and 1850. Prophetic inventions most of them, the kind which characterize most great developments. There is a class of men who dream dreams and another class who put their dreams to some use. I think perhaps our American inventors have excelled in the latter respect, for theirs has been a wonderful record, with the telegraph, telephone, airplane, submarine, talking machine, steam navigation, machine gun, cotton gin, harvesting machinery, etc. But we must not forget that Europe, too, has had her victories of invention. Here was the steam engine, the gas engine, the dynamo, both direct and alternating-current, the steam turbine, the locomotive, spinning machinery, the X-ray, radium and many others.

The steam turbine began its practical use on the other side. Parsons blazed the way, and at about the same time Delaval. Parsons built his first turbine in 1884 and for many years thereafter built a goodly number of what we would now call very small machines. In the year 1896 Mr. Westinghouse acquired the American rights for the Parsons turbine. After some years of development work we installed in 1889 three 400-kw. machines in the air-brake company's plant at Wilmerding. They are running yet.

In 1900 we put our first turbine out into the customer's hands. This was a 2000-kw. machine which we furnished to the Hartford Electric Light Co. It was double the capacity of any other turbine then in use, and European engineers looked upon it as a daring piece of work to put so large a capacity in one cylinder construction. Well, the business grew, and in truth the steam turbine made possible the tremendous strides that our electrical industry has made. This I shall try to make clearer in a moment. By 1905 our largest unit had grown to 7500-kw.; in 1909, 10,000; in 1913, 20,000; 1917, 35,000, and in 1918, 60,000 kw. Where will it end?

We cannot properly consider the steam turbine and the place it occupies without thinking about the electrical industry as a whole, for the turbo-generator is an electrical device; it generates electric current. I am going to show you in a few moments pictures of the largest power plants in the country some fifteen years ago. Beautiful plants they were, operating with reciprocating engines. One of them had eleven 3500-kw. units, the other eight 7500-kw. units. These plants were in New York City. The piston engine had reached its maximum size at 7500 kw. It was a ponderous thing. The engine and generator combined weighed nearly 2,000,000 lb. The diameter of the generator was 40 ft. We had to build a special shop in which to make it. And think of it! Only 7500 kw.! The engine had four cylinders, two horizontal and two vertical. Even then, divided that way, the low-pressure cylinders were 88 in. in diameter, which was felt to be about as large as a steam cylinder could be safely built. This plant of 60,000-kw. capacity was the last word in power-plant design. It had a fuel record of 2½ lb. of coal per kilowatt-hour. Those engine units cost originally about $175,000 each. After running about 15 years they were broken up and scrapped at a salvage of about $10,000 apiece and replaced with turbines of 30,000 kw. each, the plan being to install 240,000 kw., an increase in power of 4 to 1. Their original boiler equipment was not increased, though the furnaces were rearranged. The engines had required about 17.5 lb. of steam per kw-hr. The turbines took about 11 lb. The engine units weighed 280 lb. per kilowatt, the turbines about 45 lb. The comparative floor space was in favor of the turbine in the ratio of 1 to 10. The original station cost $128 per kilowatt installed capacity. On the basis of writing off the engine units entirely, the cost of the plant with the full complement of turbines was $42 per kilowatt.

The electrical industry has grown beyond our dreams until we have in this country today some ten million kilowatts of central-station capacity—about two-thirds of it steam power and one-third water power. It ministers to the necessities and the comfort of perhaps 65 per cent. of our population, which is about the proportion of those who live under electric wires. These people average to consume about 400 kw.-hr. per annum per capita. Here in Pittsburgh the consumption is around 600. The population of our country doubles about every twenty years. During the past two decades the per capita consumption of electricity has doubled about every five years. It takes now about 1/7 kw. installed capacity to serve the needs of each man, woman and child in American communities. This result would have been economically impossible with any other form of prime mover.

*From a talk before the Duquesne Light and Power Company's section of the National Electric Light Association.

Canadian Commission of Conservation on Pulverized Fuel

The Commission of Conservation of the Dominion of Canada has just issued a 57-page pamphlet dealing with the subject of powdered fuel and compiled by William J. Dick. The first 12 pages are devoted to data setting forth the shortage of coal in Canada and the increasing difficulties of obtaining fuel oil. It is to be noted that little is said by the commission itself about powdered fuel, the following being the most pertinent statement in the pamphlet and expressive of the commission's opinion:

"The economy secured by the use of pulverized fuel in stationary boilers instead of hand-fired coal is not so great in comparison as that derived from its use in locomotives. This is due largely to the fact that it is possible to equip stationary plants with the best mechanical stokers. There is an advantage of 2 or 3 per cent. in combustion efficiency in favor of pulverized coal, but this is offset by the additional cost of fuel preparation. While the above comparison is made from the standpoint of efficiency, and where almost similar coal is used, there are many localities, especially in northern Ontario, and portions of Manitoba, Saskatchewan and Alberta, where pulverized peat or pulverized coal could be used to decided economic advantage instead of higher-priced imported coal."

The remaining 44 pages of the pamphlet are devoted chiefly to reprints of descriptions of pulverized coal-burning equipment.

Industrial Safety Conference

In the absence from Washington of the Director of the Bureau of Standards, Dr. S. W. Stratton, the meeting of the Industrial Safety Conference on Dec. 8, 1919, was called to order by Dr. E. B. Rosa, who summarized at some length the events leading up to this conference and referred especially to the proceedings of the similar conference held on Jan. 15, 1919, of which this in a sense was an adjourned meeting.

The principal subjects which came up at the January conference were the reorganization of the American Engineering Standards Committee and the question of whether the safety work of the Bureau of Standards should be conducted under the scheme of procedure laid down by that committee. The result of a letter ballot was a decided majority in favor of procedure under the plan of the American Engineering Standards Committee. This committee has adopted, since the January conference, a revised constitution which opens its membership to other organizations in addition to the original five founder societies and three Government departments.

Prof. Comfort A. Adams, chairman of the American Engineering Standards Committee, spoke on the work of that committee and its recent reorganization. Membership in the committee is now open to such organizations or groups of organizations of national scope as may be approved; there shall be no more than three members from each such organization, and the annual dues are $500 for each representative. The speaker stated that he would be superseded as chairman of the committee by A. A. Stevenson, and that the permanent secretary will be Dr. P. G. Agnew, at present in the Bureau of Standards. Headquarters will be in New York City.

Chester C. Rausch, of the Safety Institute of America, introduced the following resolution which was adopted by the Conference:

Resolved: (1) That the American Engineering Standards Committee be asked to request the International Association of Industrial Accident Boards and Commissions, the Bureau of Standards and the National Safety Council to organize a joint committee on safety codes, this committee to include representatives of these bodies and such others as they may consider advisable; (2) that this joint committee report upon the safety codes required, priority of consideration of the codes, and sponsor bodies for their preparation; (3) that this report be put in writing and placed not later than Feb. 1, 1920, in the hands of the American Engineering Standards Committee.

Before taking the vote on this, however, another motion was passed confirming the result of the letter ballot taken last spring and expressing the decision of the conference that safety codes should be established under the procedure of the American Engineering Standards Committee.

In the discussion on this subject it was pointed out that the American Engineering Standards Committee was not primarily interested in safety matters and that the committee contemplated in the resolution of Mr. Rausch would be directly concerned in such matters and might well serve as a steering committee on safety-code work. The opinion was freely expressed that such a committee should be a permanent one, that it should contain representatives of all interests involved in safety codes and that it might well be called a National Safety Code Conference and hold annual meetings. Such a committee would be in a position to coördinate work on safety codes, to arrange for necessary interpretations, to initiate new codes as they become necessary, and to form a central agency to insure coöperation.

Hydro-Electric Development in Czecho Slovakia

A scheme for the utilization of the water powers in Czecho-Slovakia, which are estimated at 800,000 hp., has been approved by a bill adopted by the National Assembly. The installations necessary for laying out all the territory for the use of electricity will require an expenditure of 2,000,000,000 crowns ($400,000,000) for the hydraulic work, 500,000,000 crowns ($100,000,000) for the central stations, and 1,000,000,000 crowns ($200,000,000) for the distribution of electricity. It is calculated that the total revenue from the consumption of energy will reach 1,000,000,000 crowns ($200,000,000) per annum.

According to the law in question an annual credit of 75,000,000 crowns ($15,000,000) is to be entered in the budget estimates for the years 1919 to 1923, and two-thirds of this amount will be devoted to the construction of hydro-electric works, and the balance will represent the financial participation of the State in the working of undertakings for the production and distribution of energy. The State, departments, and the communes will alone or in coöperation with existing electricity companies take up 60 per cent. of the capital so as to secure influence in the undertakings, while private capital will be admitted only up to 40 per cent. Part of the capital to be raised will be covered by the issue of bonds and debentures. The sum of 8,000,000 crowns ($1,600,000) out of the total amount voted by the National Assembly will be placed at the disposal of the undertakings for the current financial year. The scheme aims at the establishment of nine large electrical undertakings, of which four would be in Bohemia, three in Moravia, one in Silesia, and one in Slovakia.—*The Electrical Review, London.*

Gadsden-Huntsville Extension

Capt. W. P. Lay, of the Alabama Power Co., states that the company's high-tension line from Gadsden to Huntsville, construction of which has just begun, is part of a plan to build a power loop, which will be one of the longest and most important in the world.

The company has a line from Lock 12 on the Coosa River to Birmingham, and from that point to Sheffield and Florence. From the same generating station another line branches out to the eastern side of the state, passing through Sylacauga, Talladega and Annison to Gadsden. With the completion of the extension to Huntsville it will be necessary to build between that city and Florence, a matter of only a few miles, to complete the loop which will belt the entire mineral and industrial section of Alabama.

This loop will be completed as early as possible, Captain Lay states, in order to connect a complete system of electric-power transmission, a system that will tap all towns and cities from the Tennessee River to Central Alabama and as far down as Selma.

Two emergency steam plants, together capable of taking care of any emergency from breaks or accidents, are stationed on this loop. They are located at strategic points, one being on the Warrior River below Birmingham and the other on the Coosa River at Gadsden.

Ten Hints for the Storage of Bituminous Coal

Tests conducted by the Bureau of Mines lead to the following conclusions regarding the storage of any bituminous coal:

1. Piles not to be over 12 ft. deep and no part of the interior to be over 10 ft. from the surface.
2. Store only screened lump coal—if possible.
3. Keep out dust as much as possible, and to do this avoid handling.
4. Have lump and fine evenly distributed. Do not let lumps roll to the bottom and form air passages.
5. Rehandle the screenings after two months, if possible.
6. Store away from any sources of even moderate heat and well away from the main buildings of the plant; never against a frame building.
7. Allow six weeks' seasoning after mining before putting into storage piles.
8. Avoid alternate wetting and drying.
9. Avoid admission of air to the interior of the pile through interstices around timbers, irregular brickwork or a porous bottom, such as coarse cinders.
10. If wet coal is received, dump in small piles around the edges, where air can get to it freely to carry away moisture, and where other coal will not be packed on top of it.

Oil Fire Efficiency Boosted by Orsat

Guy L. Bailey, manager, Municipal Light and Power Co., San Francisco, Calif., states that to get information as to the efficiency of the furnaces in the Municipal Light and Power Co.'s plant on Stevenson St., Orsat apparatuses were installed in the fireroom. The four boilers were of Stirling make, and the flue-gas samples were taken about a foot below the damper. The determinations were of great value at this time in educating the firemen as to the amount of air required.

"All of our men," says Mr. Bailey, "were experienced in the burning of fuel oil, but they were firing with from 80 to over 150 per cent. excess air. By shutting down on the draft and making frequent determinations with the Orsat until a high percentage of CO_2 was obtained, the firemen were taught how the fire should appear with the minimum amount of air for complete combustion. The men were unable to get much better than 12 per cent. CO_2 as above this point the fire was likely to smoke. The second month showed an increase of 19.3 per cent. in kilowatt-hours per barrel of oil obtained the month before installing the Orsat. This improvement was responsible, in small part, to the fact that the load factor on the turbine increased from 43 to 53½ per cent."—From *Transactions A.S.M.E.*

New Publications

A STUDY OF THE FORMS IN WHICH SULPHUR OCCURS IN COAL. By A. R. Powell with S. W. Parr, Bulletin No. 111, Engineering Equipment Station, University of Illinois, Urbana, Ill. 62 pages.

This bulletin is a report of investigations made to study the nature of the sulphur-containing compounds in coal, the quantity of each form present and the change which the form undergoes when the coal is allowed to stand or when it is coked. A knowledge of these points would have a practical bearing on the spontaneous combustion of coal and on the control of the sulphur content of coke. The bulletin gives a detailed account of the experimental chemical work performed in the development of a method for analyzing the different forms of sulphur in coal and a description of the changes in the forms of sulphur. The appendices contain historical matter on the constitution of coal and on the work of other investigators along the same lines.

ROBISON'S MANUAL OF RADIO TELEGRAPHY AND TELEPHONY. By Captain S. S. Robison, U. S. Navy. Published by the Lord Baltimore Press, Baltimore, Md., 1919. Cloth, 9x6 in.; 307 pages; 144 illustrations.

This radio manual was written for the use of naval electricians, student operators and others, and presents the elementary principles of the art of radio telegraphy and telephony, together with descriptions of apparatus commonly used. This is the fifth edition of this work, which was originally written by Lieut. (now Rear Admiral) S. S. Robison, U. S. Navy, in 1907. A comprehensive treatment is given on the construction and operation of radio equipment. The subject is presented from the practical viewpoint. Particularly noticeable is the absence of mathematical treatment. The major portion of the mathematics is given in one chapter of formulas and tables, so that the book may be read with interest by even the nontechnical reader. Those that are interested in radio subjects will find a wealth of practical information in this manual.

PULVERIZED FUEL, ITS USES AND POSSIBILITIES. By William J. Dick, M. Sc. Published by the Commission of Conservation, Ottawa, Canada. Paper, 57 pages.

This pamphlet begins with a review of the general fuel situation in Canada. In this connection the fact that although Canada has over 17 per cent. of the world's coal reserve, 55 per cent. of its consumption in 1916 was imported. A history of the pulverized-fuel industry, beginning with experiments in connection with cement burning, notes its gradual extension for railroad work, in the metallurgical industries, and in stationary boilers. The difficulties encountered in burning this fuel in steam boilers are summarized as follows: (1) The difficulty of maintaining continuous and steady ignition; (2) of finding a material to stand the furnace temperatures; (3) of producing a homogeneous mixture with varying grades of coal; (4) of maintaining a homogenous mixture of fuel and air during the period required for complete combustion; and (5) of handling the molten ash. A description of the Bettington boiler, a combined boiler and pulverizing plant, outlines some of the successfull methods of overcoming these difficulties. Reports on experience with pulverized coal from a large number of cement, metallurgical and power plants are included. These reports give considerable detail, and a number of them are accompanied by data and results from tests.

Personals

A. H. C. Dalley, formerly district sales manager of the Pulverized Fuel Equipment Corporation, has been promoted to the position of assistant vice-president of the same company. As before, Mr. Dalley's headquarters is in the Peoples Gas building, Chicago.

Engineering Affairs

The American Society of Mechanical Engineers will hold its next meeting at St. Louis, Mo., May 24-27, inclusive.

The Marine Engineers' Beneficial Association will hold its 45th annual convention at Washington, D. C., Jan. 19-24, with headquarters at the Hotel Raleigh.

Miscellaneous News

Consideration of the Water Power Bill in the open Senate began Jan. 5. The time was consumed principally by Senator Lenroot of Wisconsin, who is opposing the measure.

Edison Medal Awarded to W. L. R. Emmet.—At the meeting of the Board of Directors of the American Institute of Electrical Engineers held December 12, the Edison Medal Committee reported that the Edison Medal for the year 1919 had been awarded to Mr. W. L. R. Emmet, "for inventions and developments of electrical apparatus and prime movers." Arrangements will be made for the presentation of the Medal to Mr. Emmet at a convenient later date.

Business Items

Union Renewable Fuses, manufactured by the Chicago Fuse Manufacturing Co., Chicago and New York, have been approved by the Underwriters Laboratories of the National Board of Fire Underwriters, in capacity from 1 to 600 amperes. This action by the Underwriters will doubtless meet the approval of users of fuses.

The Reading Iron Co., Reading, Penn., has recently opened new district sales offices in Pittsburgh and Chicago. F. M. English has been appointed district sales manager in charge of the Pittsburgh office and R. A. Griffin, district sales manager in charge of the Chicago office. Craig Geddis has been appointed advertising manager and W. E. Dunham, production manager.

Trade Catalogs

The Schutte & Koerting Co. has lately issued a pamphlet entitled "Our Part in the War," and will take pleasure in mailing a copy to those applying for same.

Schutte & Koerting Co. desires to announce that it has issued a revised 8-B catalog on "Stop, Stop Check and Emergency Valves," and will be pleased to forward a copy to those interested in same.

The McAlear Manufacturing Co., Chicago, Ill., announces that its new catalog No. 25, entitled "25 Years of Know How," covering vacuum, vapor and air line heating specialties, is now ready and will be sent to anybody free upon request.

The Bailey Meter Co., Cleveland, Ohio, has recently issued its Bulletin No. 30, on "Fluid Meters for Low Pressure Gas and Air." A very complete description, with illustrations, of this type of meter. A copy of the bulletin may be had free upon request.

The second edition of "12 Reasons Why" is a bulletin describing the Hagan Steam Jet Ash Conveyor, made by the Hagan Corporation, Pittsburgh, Penn. Each of the "12 Reasons Why" is illustrated with line drawings and detailed description. A copy of this bulletin may be secured on request.

The Hagan System of Boiler Regulation is the title of a new 32-page pamphlet issued by the Hagan Corporation, Pittsburgh, Penn. The pamphlet goes minutely into the question of good and bad boiler regulations, showing how regulators improperly designed so often defeat the purpose for which they were installed. The Hagan idea of Regulating Boilers by Control from Steam Flow rather than from Steam Pressure is described in detail, using some interesting charts and curves to illustrate its advantages. Copies of this pamphlet are available on request.